JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CX. DECEMBER, 1880. No. 6.

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ACCOUNT OF VINCOTTE'S EXPERIMENTS MADE AT WILLEBROEK, BELGIUM, ON A TUBULOUS BOILER, WITH SEMI-BITUMINOUS COAL.

By Chief-Engineer ISHERWOOD, United States Navy.

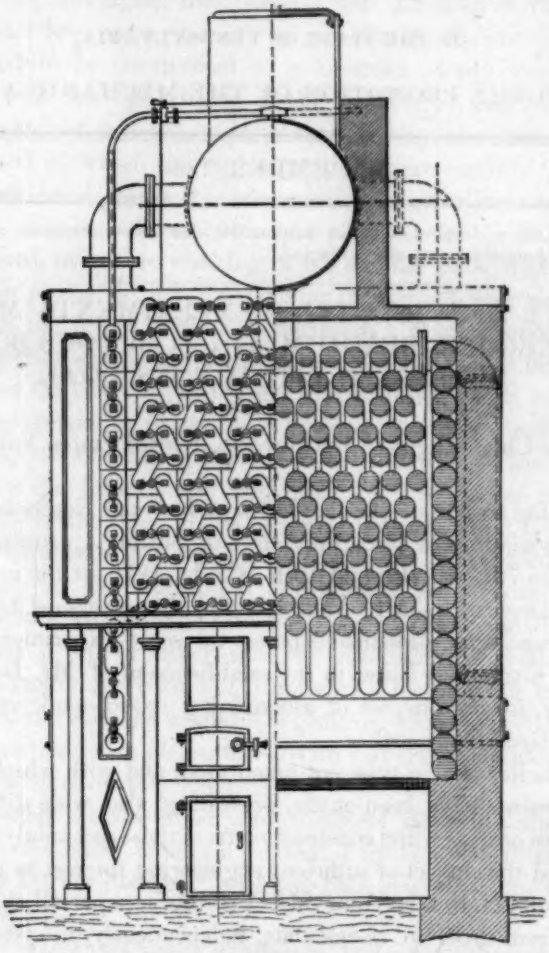
During the session of the third Congress of the Engineers-in-Chief of the Associations of the Proprietors of Steam Apparatus, held in Paris on the 7th, 8th, 9th and 10th of July, 1878, at the rooms of the Parisian Association, Mr. Vincotte, the Engineer-in-Chief of the Belgian Association, presented a paper on some experiments he had made with a tubulous boiler in the establishment of Mr. Denaeyer, at Willebroek, for the purpose of ascertaining its economic vaporization with semi-bituminous coal.

As this boiler is of a type not much used, and with which but very few experiments have been made, presenting, also, wide differences in its principles of design and construction from those commonly employed, I considered the subject of sufficient engineering interest to the readers of the JOURNAL to take from Mr. Vincotte's paper all the observed data, and from them to re-calculate, independently, the results in the manner found by English-speaking engineers the most convenient for practical purposes. I have given, likewise, a description of the boiler

and a calculation of its elements not in the original paper, and I have added my own remarks.

Boiler.

The boiler is composed of an assemblage of inclined water-tubes placed along the sides of and above the fire-grate, together with their



Half elevation. Cross Section.

connections; the whole being enclosed in a rectangular casing of brick masonry. The entire heating surface consists of the tubes and the

inmost sides of their connecting boxes, all of which are completely filled with water. There is no steam-superheating surface.

The steam-room is contained in a large horizontal cylinder lying immediately over the tubes and separated from them by a vaulting of brick masonry sustained on H iron girders. This cylinder is also enclosed by a rectangular casing of brick masonry; and, upon its upper side, at the front end, is a small steam-drum in the form of a vertical cylinder. The interiors of the large horizontal and the small vertical cylinders are in common, and the steam-pipe is carried from the top of the latter to the engine.

There is one furnace with a rectangular grate, and it is fired through two doors in the front, the opening for each of which is 8 inches high and 14 inches wide. The thickness of the wall through which these openings are made is 15 inches. The grate is 6·562 feet long and 6·168 feet broad, with the grate-bars in two equal lengths. The top of the grate inclines downwards 8 inches at the back, where the bridge-wall of brick masonry, 9 inches thick, rises 7 inches above it.

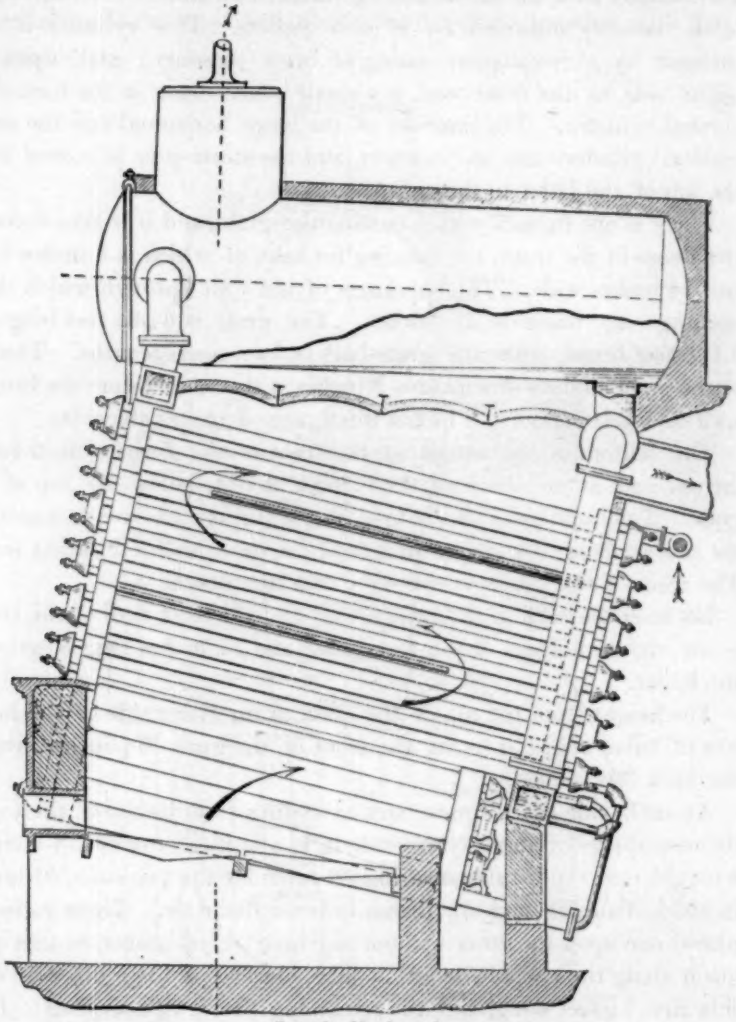
The bottom of the ashpit at the front of the furnace is 2 feet 8 inches, and at the back of the furnace 2 feet, below the top of the grate. The back, sides and bottom of the ashpit are of brick masonry; the side walls are 18 inches thick and the back wall is 9 inches thick. The front of the ashpit is closed by cast iron doors.

Between the back of the bridge-wall and the back wall of the boiler is an enclosed space 6·168 feet broad and 17 inches long lengthwise the boiler.

The height from the top of the grate to the lower side of the lower row of tubes above it is, at the front of the grate 37¾ inches, and at the back 30¾ inches.

At each side of the grate, and extending from its top to the top of the assemblage of tubes lying over it, is a vertical row of 18 inclined wrought iron water-tubes, making 36 tubes for the two sides, 5¼ inches in outer diameter and 5½ inches in inner diameter. These tubes are placed one upon the other without any intervening spaces, so that they touch along their whole length. The lower 6 of these tubes on each side are 7⅞ feet long, and the remaining 12 are 9½ feet long. They rest on a 5 inches offset in the brick wall at the side of the furnace, which wall is thence carried up 12 inches thick to the top of the boiler, the inside face of the wall and the outer ends of the horizontal diameter of the tubes touching, so that the tubes are in contact with

the wall and form a lining for it, which leaves only their inner semi-circumferences to act as heating surface. These tubes are united in pairs, alternately, at both ends, by connecting boxes of ordinary cast



Longitudinal section.

iron or of malleable cast iron, by which means the interiors of all are in common. The topmost tube on each side receives the feed-water

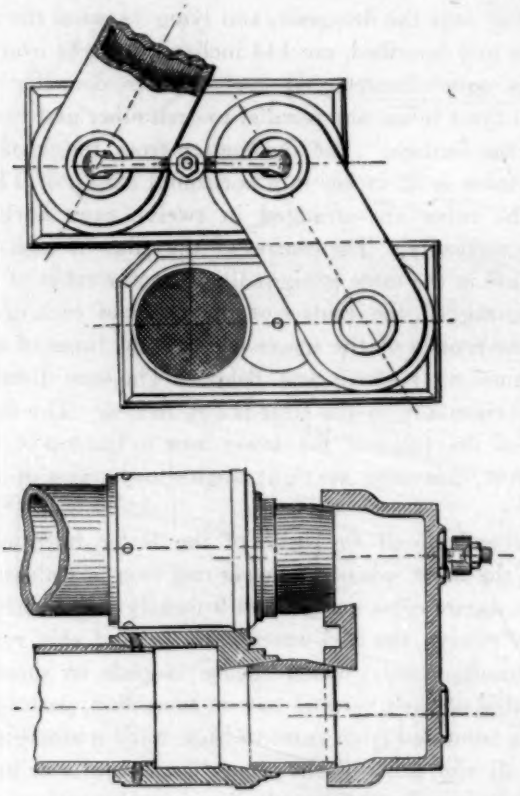
which traverses in succession all the remaining 17 tubes beneath it, and is delivered at the back end of the lowest tube into a lower cast iron box of rectangular cross section lying horizontally across the whole breadth of the boiler at its back. This box is 10 inches square on the outside, 7 inches square on the inside, and of 9 feet $2\frac{1}{4}$ inches extreme length; it is supported upon the 10 inches thick back brick wall of the boiler.

Immediately over the fire-grate, and lying between the two vertical rows of tubes just described, are 144 inclined wrought iron water-tubes of $4\frac{3}{4}$ inches outer diameter, $4\frac{1}{2}$ inches inner diameter and $9\frac{1}{2}$ feet length. All these tubes are parallel to each other and to the tubes at the sides of the furnace. The declination from the front to the back ends of the tubes is 22 inches in a horizontal length of 110 inches, or 1 in 5. The tubes are arranged in twelve rows horizontally and twelve rows vertically. The centres of the tubes of each of the horizontal rows are in the same straight line, but the tubes of the vertical rows are zig-zagged, the centres of the tubes of each of these rows being over the centres of the spaces between the tubes of the horizontal rows immediately above and below. The least distance between the tubes horizontally in the clear is $1\frac{5}{12}$ inches. The distance from the bottom of the tubes of the lower row to the top of the tubes of the upper row, measured at right angles to the axes of the tubes, is $5\frac{1}{2}$ feet.

The back ends of all the tubes of the lower horizontal row are secured into the inner side of the lower cast iron box already described of 10 inches square cross section and 9 feet $2\frac{1}{4}$ inches extreme length, whence they receive the feed-water, each tube of this row receiving the water simultaneously, which thence ascends, by suitable connections, the tubes of each vertical row in succession, passing alternately from back to front and from front to back until it emerges simultaneously from all the tubes of the upper horizontal row into an upper horizontal cast iron box of exactly the same dimensions as the lower one already described, which upper box is supported on the top of the front wall of the boiler.

The tubes of each horizontal row are secured in pairs—two adjacent tubes constituting a pair—into the inner side of a rectangular box of ordinary cast iron or malleable cast iron. The outside dimensions of each of these boxes are 11·81 inches wide, 5·91 inches high and 5·04 inches long lengthwise the boiler; least thickness of metal, $\frac{5}{8}$ inch.

These boxes being piled one upon another, and all in contact, like bricks in a wall, form the front and back walls of the boiler for the height occupied by the tubes. These fixed boxes are connected on their outside, vertically, by movable cast iron boxes, rectangular in cross section, and held in position by cross-bars secured by bolt and nut after the manner of securing manhole plates in a boiler. Every



Method of connecting Tubes.

two vertically adjacent fixed boxes, at front and rear of boiler, are connected by one movable box, which being taken off with the same degree of labor required for removing a manhole plate, exposes the interior of two tubes for examination and cleaning. In outer cross section, the movable boxes are 4·13 inches wide and 3·86 inches deep; least thickness of metal, $\frac{5}{8}$ inch.

The joints between the fixed and movable boxes are made by means of a wrought iron thimble 3¼ inches long and 3·39 inches inner diameter, the outer side of the thimble forming two frustra of cones united at their bases. The holes in the boxes for receiving these thimbles being made of corresponding bevel to the frustra, the cross-bar, bolt and nut force the beveled surfaces into metallic contact, and thus form a joint water-tight under the boiler pressure.

By means of these combined fixed and movable boxes, the water ascends from the lower horizontal cast iron box of 10 inches square cross section and 9 feet 2¼ inches length to the upper horizontal cast iron box of the same dimensions, by passing alternately forwards and backwards through the intervening tubes, ascending simultaneously each vertical row of tubes. The combined fixed and movable boxes answer exactly the same purpose as the cast iron bends with ordinary steam-heaters for rooms, with the advantage of easy separation.

All the tubes are roofed over by a brick vaulting 2½ inches thick, supported on iron girders of H cross section. This vaulting extends from the front to the back wall, and between the side walls of the boiler, thus completing the entire enclosure of the tubes and furnace. A horizontal wrought iron conduit carries the gases of combustion from the top of the back end of this enclosure to the chimney.

Immediately above the vaulting is a large horizontal wrought iron cylinder, with segments of spheres for ends. The cylindrical part is 41 inches in external diameter and 11⅓ feet in length. The axis is in the vertical plane passing longitudinally through the centre of the boiler; and the cylinder, with the exception of the front end, is encased in brick masonry the outside of which is rectangular.

At the front end of this large horizontal cylinder and upon its top is a small vertical wrought iron cylindrical steam-drum of 31½ inches diameter and 27½ inches height, with a flat top, from which the steam is taken to the engine. Only the lower portion of this steam-drum to a small extent is cased in masonry. The object of carrying up this small steam-drum was to obtain height of steam-room to insure a supply of dry steam.

The interiors of both cylinders are in common and constitute the steam-room, which was of very great capacity proportionally to the capacity of the engine cylinder and its speed of piston. A small portion of the lower part of the large cylinder is occupied by water,

which, entering at the front end with the steam, passes out at the back end by a pipe to be described.

The large horizontal cylinder communicates on each side of its forward end, on the level of its horizontal diameter, with the two ends of the upper horizontal cast iron box of 10 inches square cross section and 9 feet 2¼ inches extreme length, by means of curved pipes 9 inches in diameter, through which the cylinder receives the steam generated on the tube surfaces, and any water that may come with it.

At the bottom of the back end of the large horizontal cylinder a pipe of 10 inches diameter and 12 inches length communicates with the centre of a horizontal pipe of 8 inches diameter, lying upon the top of the back wall of the boiler. This horizontal pipe has a length equal to the breadth of the boiler, and from each extremity a vertical pipe of 8 inches diameter descends to the corresponding extremities of the lower horizontal cast iron box of 10 inches square cross section and 9 feet 2¼ inches extreme length, thus completing the circulation of the water.

In order that the gases of combustion may pass over the entire tube surface, instead of taking a straight course from the grate to the chimney outlet, two diaphragm plates of wrought iron are introduced horizontally betweeu the tubes, one above the other, in such manner as to equally divide the tubes. Both diaphragms extend entirely across the boiler, with one end touching either the front or back wall of the boiler, and leaving between the other or free end and the front or back wall, as the case might be, a sufficient space for the passage of the gases. The lower diaphragm leaves this space between its free end and the back wall of the boiler 2 feet 3 inches; the upper diaphragm leaves this space between its free end and the front wall of the boiler 1 foot 5 inches; so that the gases, after passing over the lower four horizontal rows of tubes in a direction from front to back, returns from back to front over the next four horizontal rows, and, finally, takes their original direction from front to back over the remaining four rows.

From the foregoing description of the boiler will be seen that unusual precautions were taken to keep the current of the gases of combustion thoroughly broken up and mixed, and to compel it to pass over the whole of the heating surface: the zig-zagging of the tubes, their position in the current which had to pass over them in a direction at right angles to their length, as well as in the direction of their

length, and the deflections produced by the diaphragms, causing the whole of the gases to pass in succession over only one-third of the tubes at a time, must have accomplished very completely the purpose.

The following are the principal dimensions and proportions of the boiler:

Length over all, including masonry,	13 feet 8 inches.
Breadth over all, including masonry,	9 feet 2 inches.
Height from bottom of ashpit to top of large horizontal cylinder,	15 feet 4 inches.
Breadth of grate,	6·168 feet.
Length of grate,	6·562 feet.
Grate surface,	40·4744 sq. ft.
Number of tubes at sides of furnace,	36.
Exterior diameter of tubes at sides of furnace,	5¾ inches.
Interior diameter of tubes at sides of furnace,	5½ inches.
Length of 12 of the tubes at the sides of the furnace.	7 feet 10½ inches.
Length of the remaining 24 tubes at the sides of the furnace,	9 feet 6 inches.
Number of tubes immediately over the grate,	144.
Exterior diameter of tubes immediately over the grate,	4¾ inches.
Interior diameter of tubes immediately over the grate,	4½ inches.
Length of the tubes immediately over the grate,	9 feet 6 inches.
Area of heating surface in tubes at side of furnace, calculated for half their inner circumference,	232·1821 sq. ft.
Area of heating surface in tubes at sides of furnace, calculated for half their outer circumference,	242·7369 sq. ft.
Area of heating surface in tubes immediately over grate, calculated for their inner circumference,	1611·6408 sq. ft.
Area of heating surface in tubes immediately over grate, calculated for their outer circumference,	1701·1764 sq. ft.
Area of all other heating surface,	44·0000 sq. ft.
Aggregate area of heating surface, calculated for inner circumference of the tubes,	1887·8229 sq. ft.
Aggregate area of heating surface, calculated for outer circumference of the tubes,	1987·9133 sq. ft.
Aggregate cross area between tubes horizontally,	9·2962 sq. ft.

Cross area between lower diaphragm and back wall of boiler,	2·2017 sq. ft.
Cross area between upper diaphragm and front wall of boiler,	1·3863 sq. ft.
Length traversed by the gases of combustion from centre of furnace to chimney outlet,	22 feet.
Exterior radiating surface of the cast iron boxes forming the front and back walls of the boiler,	269 square feet.
Water-room,	226·1 cub. feet.
Steam-room,	102·5 cub. feet.
Square feet of heating surface per square foot of grate surface, calculated for inner circumference of tubes,	46·6424.
Square feet of heating surface per square foot of grate surface, calculated for outer circumference of tubes,	49·1153.
Square feet of grate surface per square foot of opening for draught at lower diaphragm,	18·3832.
Square feet of grate surface per square foot of opening for draught at upper diaphragm,	29·1960.

Coal.

The coal consumed during the experiments with this boiler was semi-bituminous, from the mines of Monceau-Fontaine. It was an excellent steam-coal, and before being used had its dust separated by screening.

Analyses were made of two specimens, with closely agreeing results, of which the following are the mean:

Composition of the Crude Coal.

Hygrometric moisture,	2·80
Carbon,	78·57
Hydrogen,	3·85
Oxygen,	3·49
Nitrogen,	0·87
Sulphur,	0·42
Ash,	10·00
	100·00

Composition exclusive of Hygrometric Moisture and Ash.

Carbon,	90·10
Hydrogen,	4·42
Oxygen,	4·00
Nitrogen,	1·00
Sulphur,	0·48
	100·00

By Distillation in a Retort.

Volatile matters,	13·6
Coke,	86·4
	100·0

Manner of Making the Experiments.

The experiments occupied five working days, four of which were consecutive; the time in each day being 11 hours 11 minutes, 11 hours 5 minutes, 11 hours 40 minutes, 11 hours 44 minutes and 11 hours 30 minutes; making an aggregate of 57 hours 10 minutes. During these days the steam from the boiler was used in driving a steam-engine.

At the commencement of each day the boiler was kept for two hours with regular fire in the furnace and under the regular working steam pressure, in order that all parts might attain the temperature due to that pressure before beginning the experiment, the working pressure varying but a mere trifle for the different days.

At the expiration of the two hours the fire was wholly withdrawn from the furnace and a new fire kindled with a small quantity of wood, which was weighed, and its equivalent weight in coal added to the weight of coal consumed during the day. At the end of the day the fire was burned completely out, the water level and steam-pressure in the boiler being left the same as at the commencement.

The boiler was nearly new and perfectly clean. The tubes, as far as accessible, were swept of soot each morning before commencing an experiment, and again in the middle of the day.

The feed-pump supplied no other boiler, and at the commencement of the experiments all the connections with other boilers were broken, so that the experimental boiler was completely isolated. Before commencing the experiments the boiler was carefully tested under pressure for leaks, and found perfectly tight.

The feed-water was the water of condensation of the exhaust steam from the engine, increased by the quantity of fresh water required to make good the wastage. The steam produced in the boiler after being used in the engine was exhausted into a surface condenser, and thence the resulting water of condensation was delivered for measurement into a rectangular tank containing 6·71 cubic feet, from which it was again pumped into the boiler. The amount thus collected was found, by careful measurement during the five days, to be 7 per thousand less than the total quantity required to feed the boiler, which 7 per thousand was added in fresh water and is included in the vaporization given in the following table. This difference was due to spontaneous vaporization of the hot feed-water in the measuring tank, the temperature averaging 117 degrees Fahrenheit, and to losses at the safety-valve.

The coal was weighed every hour. The boiler pressure and the temperature of the feed-water were noted every half-hour. The fires were skillfully managed by an experienced fireman, and could not during any working day have needed much cleaning.

The most careful and varied observations failed to discover that any water was "primed" over from the boiler or entrained by the steam, the latter, in response to all tests, showing perfectly dry.

The maximum rate of combustion that could be sustained was 13½ pounds of crude coal per hour per square foot of grate; the mean rate during the experiments was 9 pounds, so that the experimental rate was two-thirds of the maximum. As the chimney was in common for other boilers and purposes, the maximum rate of combustion is not due to the temperature of the gases discharged into it from the experimental boiler alone.

During the experiments the rate of combustion was considerably varied within the above limit for the maximum, but without certain effect upon the economic vaporization of the water, the difference in that result being but slight, not following any law, and having about the irregularity to be expected from unavoidable errors of observation and differences of condition which could neither be known nor allowed for if known. Consequently, the mean of the entire five days' experimenting are given in the following table, as being more accurate than the results from each day taken separately: the longer the time and the greater the number of observations the more reliable becomes the final result.

During the experiments the exterior surfaces of the cast iron boxes forming the front and back walls of the boiler above the top of the furnace were in contact with the external air and without protection from radiating heat. The temperature of the water within these boxes was 291 degrees Fahrenheit, and the surface thus exposed was 269 square feet. The joints between the boxes not being tight, considerable leakages of air must have there taken place into the gases of combustion, as well as through the walls of brick masonry.

Attempts to ascertain the temperature and composition of the gases of combustion when leaving the boiler were made, but, owing to the excessive inleakages of air and other causes, nothing reliable could be obtained in these respects.

In the following table will be found the data and mean results of the experiments for the five days aggregated. In reducing the weight of water vaporized to standard conditions, due allowance has been made for its variation in specific heat at different temperatures, and for the difference in the total heat of steam at different pressures.

Table containing the Data and Results of the Experiments made on the 26th, 27th, 28th and 29th of June, and on the 4th of July, 1878, by Mr. Vincotte with the Tubulous Boiler belonging to Mr. Denaeyer, at Willebroek, Belgium, to ascertain its Economic Vaporization of Water by Semi-Bituminous Coal.

Total Quantities.	Aggregate duration of experiments, in hours and minutes,	57″ 10
	Aggregate number of pounds of crude coal consumed,	20767·
	Aggregate number of pounds of refuse from the coal, in clinker, ash, etc.,	2967·
	Aggregate number of pounds of combustible or gasifiable portion of the crude coal consumed,	17800·
	Per centum of the crude ocal in refuse of clinker, ash, etc.,	14·29
	Aggregate number of cubic feet of feed-water vaporized, measured in tank,	2812·9300
	Aggregate number of pounds of feed-water vaporized from its temperature in the tank,	173637·3925
Temperature and Pressure.	Mean temperature of the feed water, in degrees Fahrenheit,	117·
	Mean pressure of steam in boiler, in pounds per square inch, above atmosphere,	44·

Rate of Combustion.	Number of pounds of crude coal consumed per hour,	363·2711
	Number of pounds of combustible consumed per hour,	311·3703
	Number of pounds of crude coal consumed per hour per square foot of grate,	8·9753
	Number of pounds of combustible consumed per hour per square foot of grate,	7·6930
	Fraction of a pound of crude coal consumed per hour per square foot of heating surface, calculated for the inner circumference of the tubes,	0·1924
	Fraction of a pound of crude coal consumed per hour per square foot of heating surface, calculated for the outer circumference of the tubes,	0·1827
	Fraction of a pound of combustible consumed per hour per square foot of heating surface, calculated for the inner circumference of the tubes,	0·1649
	Fraction of a pound of combustible consumed per hour per square foot of heating surface, calculated for the outer circumference of the tubes,	0·1569
Vaporization. Absolute.	Number of pounds of water that would have been vaporized had it been supplied at the temperature of 100 degrees Fahrenheit and vaporized under the standard atmospheric pressure,	174777·5523
	Number of pounds of water that would have been vaporized had it been supplied at the temperature of 212 degrees Fahrenheit and vaporized under the standard atmospheric pressure,	195198·6723
Economic.	Pounds of water vaporized from 100° Fahrenheit by one pound of crude coal,	8·4161
	Pounds of water vaporized from 100° Fahrenheit by one pound of combustible,	9·8189
	Pounds of water vaporized from 212° Fahrenheit by one pound of crude coal,	9·3995
	Pounds of water vaporized from 212° Fahrenheit by one pound of combustible,	10·9662

Remarks.

The economic vaporization given by marine boilers of the water-tube system, consuming good steam-coal at the same rate per square foot of heating surface as in the case of the boiler experimented with, is, according to numerous experiments made in the Navy, 13 pounds of water vaporized from the temperature of 212 degrees Fahrenheit, under the standard atmospheric pressure, by one pound of the combustible portion of the coal. But in the boiler experimented with only 11 pounds of water were vaporized under these conditions,

or it was economically inferior to the marine boiler by about $\left(\frac{13-11\times100}{13}=\right)$ 15½ per centum. This lessened economic efficiency was undoubtedly caused by the leakage of air through the joints of the cast iron boxes forming the front and back walls of the boiler above the furnace, and through the other walls of brick masonry, into the gases of combustion passing over the heating surfaces.

The air thus leaked in carries with it to the chimney the quantity of heat required to raise its temperature from that of the external atmosphere to the temperature of the gases leaving the boiler. This, however, does not include the prejudicial effect on the economic vaporization caused by the degradation of the temperature of the gases of combustion consequent on the mingling with them of the inleaked colder air; for only the excess of the temperature of the mingled air and gases over that of the boiler-water can be applied vaporifically. As an extreme example, suppose the quantity of cold inleaked air to be so great as to make the temperature of the mingled gases and air that of the water in the boiler, then, although the same quantity of heat would pass over the heating surface as before, yet none of it could be applied to the production of steam, and the whole of the fuel consumed would be absolutely lost in that respect, all the heat generated by its combustion passing into the chimney.

The mingling of cold air with the gases of combustion, by reducing the chimney temperature, reduces the force of the draught of the boiler, so that less fuel is consumed in equal times, and the draught is likewise made additionally sluggish by the greater quantity of gaseous matter to be passed in equal times through the chimney; and the economic vaporization is also decreased because the rapidity with which heat passes from the hot gases to the water in the boiler is in the proportion of the difference of the temperatures of the water and gases. In every point of view the inleakage of cold air is highly disadvantageous to both the economic and the potential vaporization by a boiler, and should be carefully guarded against. The waste of fuel in land boilers set in brick masonry, due to this cause, is enormous and the consequence of pure ignorance.

The water in the boiler was analyzed each day, and the following was its mean composition by weight:

Water,	999·2015
Lime,	0·1429
Magnesia,	0·0054
Alkalies,	0·1444
Chlorine,	0·2149
Sulphuric acid,	0·2865
Carbonic acid,	0·0044
	1000·0000

This water was alkaline, but its alkalinity, which was due to the magnesia and, probably, lime resulting from the decomposition of the carbonates of these two bases, was lost by the calcination of the solid matters dissolved in it. These two oxides are found in the solid residue in presence of organic matter which during the circulation furnished them with carbonic acid.

An examination of the water of condensation drawn from the surface condenser showed it to be strongly acid and containing iron, while the water in the boiler from which it was distilled was alkaline and free of iron. The acid was found to be carbonic acid; the iron was in the state of carbonate of iron, and came from the iron tubes of the surface condenser. The action on these tubes was so rapid that the clear water of condensation after standing one night in the condenser was discolored and ochrous in the morning. This water, after the removal of the acid and iron, was absolutely pure. If the water was allowed to stand, the acid left it spontaneously, and at the end of about fifteen days was nearly all gone.

The writer has observed the same destructive action of the water of condensation on the cast iron shell of the surface condensers of marine engines, due to the gaseous acids brought over with the steam from the boiler and dissolved anew in that water. It is quite an error to suppose the water of condensation obtained from a surface condenser in ordinary use is pure distilled water: it is both acid and ochrous.

That no water was "primed" over, or entrained by the steam during the experiments, was due to the large capacity of the steam-drums and to their height above the water level, as other boilers of the same type, not so well provided in these particulars, are found to prime considerably, though such steam-drums do not belong to the theory of this kind of boilers.

One of the great advantages of a boiler like the one experimented

with, in which the water is contained in small tubes, is its less probability of explosion, and the less destructive effects should an explosion happen, than in the case of boilers with either cylindrical shells or rectangular shells stayed at intervals. The less probability of explosion results from the fact that the small tube is stronger to resist a given internal pressure than a large cylinder or stayed flat surface. The less destructive effects of an explosion, should one occur, results from the fact that the boiler composed of small tubes contains less water for a given heating surface than those whose shells are cylindrical or rectangular.

The explosion of a boiler is not instantaneous; it is progressive. Its more or less violence depends on the force accumulated in the boiler, and on the duration of the explosion itself. The force accumulated depends almost exclusively on the quantity and temperature of the water. Suppose, for example, that a cubic foot of water heated in a boiler to the temperature corresponding with a pressure of 60 pounds per square inch above the atmosphere, should be suddenly discharged into the air, it would produce about 185 cubic feet of steam of atmospheric pressure. Let the volume of steam in the steam-room of a boiler under the supposed pressure be the greatest given in practice, it will bear but a feeble proportion when expanded to the atmospheric pressure to the volume which will be produced from the water in that boiler, and it will contribute to the destructive effects of the explosion only in that proportion. Practically, the distance to which the destructive effects of a boiler explosion extends, and the intensity of the destruction, increase in proportion to the quantity of water contained in the boiler and to the temperature of that water.

When one or more plates of a boiler are ruptured by the pressure, a considerable fraction of its contained water passes into steam under the lessened pressure thus produced, and this transformation takes place suddenly on all the particles of the water, in measure and to the extent as they emerge into the gradually lessening pressure; so that it depends on the size and situation of the first rupture relatively to the objects in front, whether the steam they thus encounter is sufficient to destroy them. The explosion of a boiler containing but little water may sometimes kill those who are in close proximity, but the destructive effects are small and limited to the near locality. When, on the contrary, the quantity of water in the boiler is large, the surrounding

objects and the fragments of the boiler itself are violently hurled by the explosion and its destructive effects extended into remote places.

From the foregoing considerations it would seem that, in function of safety, boilers should be composed of separate similar parts, the more numerous the better, other things equal, and that each part should contain the minimum of water, conditions which are well fulfilled in the boiler experimented with, whose every vertical row of connected tubes may be considered as a complete and separate system; so that in the event of an explosion there would be but little water to cause destruction, and that the water in the different parts would flow slowly and in succession towards the fracture for projection into the air, thus rendering the discharge as prolonged as possible, and the effect, consequently, a minimum in intensity.

These conditions, unfortunately, have but a limited application. The free circulation of the water in the restricted separate parts is much impeded, and the small quantity of water itself becomes a serious defect in view of the difficulty of maintaining with it a uniform pressure of steam. The less the mass of water the less constant is the pressure.

When the fires are urged beyond a certain point the steam is so rapidly formed in the tubes, proportionally to the vent for its escape, that notwithstanding the considerable inclination given to them, the water is driven out at both ends, to return again, intermittingly, upon the metal overheated in its intervals of absence. As the tubes lie directly over the grate, the heat comes equally upon nearly the whole length of the four lower rows, so that there is nothing but their inclination to produce a circulation of water. These lower rows are impinged on by the gases of combustion at their maximum temperature as they first rise from the incandescent coal whose radiant heats also acts at the same time equally upon their whole length, so that the generation of steam must be enormously rapid there, while the only means of producing a circulation or water current through these tubes is the difference in the heads of water at their two ends.

This slight provision for establishing a circulation is neutralized in sea-going steamers by their pitching, rolling or permanent heeling over under sail, so that this type of boiler is absolutely precluded from marine use on that account. Under favorable conditions it can be employed for land service, but if attempted to be used at sea will speedily be itself destroyed, and probably cause grave accidents.

The slipping on each other of the cast iron boxes at the front and back of the boiler, into which the tubes are secured by pairs, makes a provision for any unequal expansion and contraction they may undergo from differences of temperature. But, as these free joints to move are also free to admit the cold atmospheric air, the entire front and back of the boiler should be enclosed by air-tight doors, which, though adding to the cost of constructing the boiler, would materially lessen the weight of coal consumed to produce a given quantity of steam in a given time.

The heating surface per unit of area in boilers of this description, as compared with that of boilers of the usual construction, is very inefficient. Less water, other things equal, will be vaporized in them per square foot of surface, because all the stem generated in the lower tubes has to force its way, successively, through the upper tubes, alternately, from end to end, displacing to that extent the water in the latter and thus preventing its contact with the metal. In other words, less water is in contact with each unit of area of heating surface in boilers of this kind than in boilers of the ordinary construction. Hence, to obtain an equal economic vaporization, a much greater proportion of heating surface to grate surface must be given, or a much less rate of combustion adopted. In the experimental boiler there were 49·1153 square feet of heating surface to one square foot of grate surface, a proportion approaching what is given in many locomotives with their enormous rate of combustion. A well designed ordinary boiler with half this proportion of heating to grate surface, and the experimental rate of combustion, would have given equal economic and potential results. Real improvement in engineering consists in accomplishing equal effects with less expenditure of material and labor.

Digestive Ferments in Vegetables.—M. Bouchard was led to believe, by his discovery of papaine, the digestive ferment of the *Carica papaya*, that there might be a general carnivorous property in the latex of many other vegetables. Some special careful investigations confirmed him in this belief, and his experiments with the milky juice of the common fig tree showed that it contained powerful digestive properties. He proposes to continue his researches in order to discover the nature of the new principle of vegetable pepsin.—*Comptes Rendus.* C.

THE WEAKENING OF STEAM BOILERS BY CUTTING HOLES IN THE SHELL FOR DOMES AND NECKS.

By W. Barnet Le Van.

(Continued from page 323.)

The association above referred to at the time the "French" boilers were offered for their guarantee, had under consideration several instances of explosion, which had been attributed by their chief engineer to the employment of such necks, and to large openings not sufficiently strengthened, led the committee to the determination to try the matter fully. Indeed, so completely were they alive to the weakness resulting from the large holes at the base of steam domes, and the presence of domes at all, that they had for years urged members when laying down new boilers, *to dispense with domes altogether.*

It was, therefore, arranged that a proper boiler should be constructed, of the diameter adopted in daily practice, and of the usual thickness of plates, with actual manhole, mouthpieces, etc., such as are common, so that the ultimate test should be decisive.

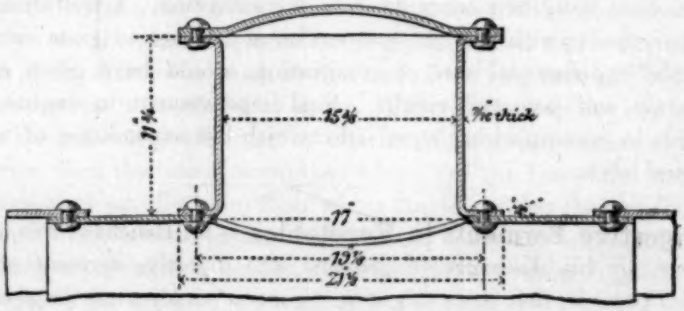


Fig. 6.

With this object then in view, they had a boiler constructed 21 feet long by 7 feet in diameter inside the inner plate of shell; with two furnace tubes 2 feet 9 inches inside diameter with flanged seams, each ring being welded up solid so that there would be no rivets or lap joint in the flue. The shell plates were $\frac{7}{16}$ inch thick, the ends

welded up solid were $\frac{1}{2}$ inch thick, and the furnace tubes of $\frac{3}{8}$ inch plate, the material throughout being of best Snedshill iron. All longitudinal joints were double-riveted, and circumferential ones single-riveted. The holes were punched.

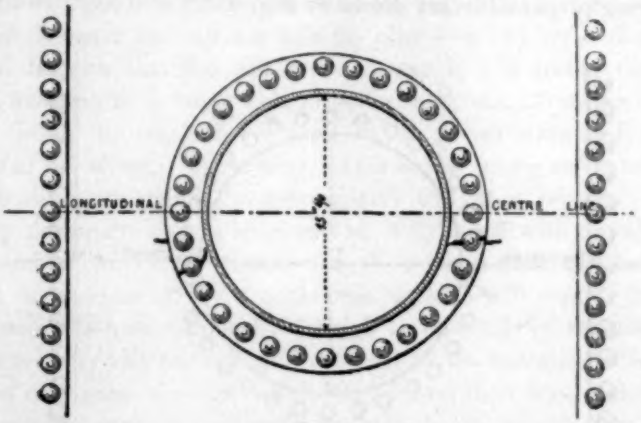


FIG. 7.

In the first experiment that was made the boiler was complete in all its details. The manhole mouthpiece was of wrought iron, such as recommended by the association. The cast-iron pipe or seating for the blow-off elbow pipe to attach to was also as is usual, while the gusset stays and longitudinal stays were the full complement provided for such a boiler for 75 pounds working pressure. The front end manhole casting was placed on the inside of the front plate and furnished with internal door and usual cross bar fixings. The wrought-iron neck on the top of boiler and on the central plate was the special object of this first experiment, and it is clearly shown in Fig. 6, in which all the dimensions are fully given. Fig. 7 is a sectional plan of this neck, and Fig. 8 shows, as does also Fig. 7, the lines where fracture ultimately took place. Before pressing the boiler up to the bursting point, careful records were taken as to the behavior of the boiler at all points, as the pressure gradually rose. The flat ends were carefully gauged to ascertain at what pressure and to what extent they gave way, and if any permanent "set" remained on withdrawal of pressure.

The furnace flues were carefully gauged; the length of the boiler shell measured by rods fixed at one end and free at the other end,

and having pointers at several places, and the circumference was also measured by two encircling steel bands passed round the boiler and weighted at each end, so that by horizontal lines drawn across them the least enlargement could be rendered clearly visible; some of these measuring preparations are shown in Fig. 9.

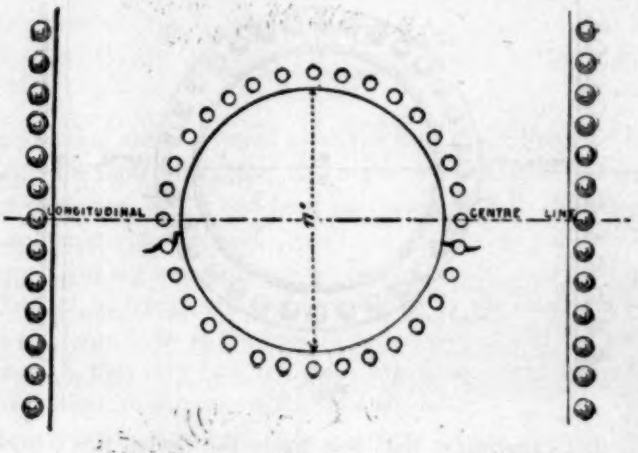


FIG. 8.

Up to the pressure at which the wrought-iron neck (Fig. 6) gave way, viz., at 250 pounds on the square inch, there was no movement of the ends beyond a slight permanent "set," which has remained the same throughout the whole of the test, even after the removel of the two longitudinal stays, by which fact it is clearly shown that the arrangement of gusset stays here used is sufficient to secure the ends up to and beyond the limit of the strength of the shell.

The first rupture took place at the base of the 14 inch neck, and is shown in Figs. 7 and 8. Of course these fractures are, in themselves, as here shown, only the commencement of the work of destruction, but it is self-evident to any one understanding the subject that had the volume of water which was supplied at the pressure of 250 pounds been greater, the rent would have extended instantly, and had steam pressure been the agent used instead of water then complete destruction must have followed, by the development of rents in various directions, and with the usual accompaniments of loud report, damage to property, and probably loss of human life.

The boiler having been repaired by the attachment of a strong circu-

lar plate where the neck had been placed, as may be seen in Fig. 9 on the top of the boiler, was furnished with a cast-iron manhole mouthpiece of the usual form. This casting was circular and was $16\frac{5}{8}$ inches inside diameter, and is shown in Fig. 10, and may here be compared with the wrought-iron manhole mouthpiece, Fig. 11, which is 17 inches internal diameter, and upon a hole in boiler shell $18\frac{7}{8}$ inches diameter. It will be seen that the cast-iron manway is $16\frac{5}{8}$ inches diameter inside, but requires a larger hole in boiler shell, viz., 20 inches diameter, to bring the edge of the plate to its proper distance from the centers of the rivets. The casting, which was of strong and substantial pattern and quite sound throughout, gave way at a pressure of 200 pounds per square inch, a large part of it flying off with considerable force, and so much more violent was the rupture than had been the case in the instance of the wrought-iron neck at 250 pounds that the shell plate was torn completely through on each side of the manhole, the rents being longitudinal until diverted by the resistance offered by the two ring seams through which they forced their way, and thence they began to pass circumferentially through the neighboring plates. Here again are clear lines of commencing rents whose ultimate development it is self-evident must have been utter destruction. The fractured portions of this casting are shown in Fig. 9, as is also the first wrought-iron neck with its fractured flange.

At the next or third experiment a steam dome 3 feet in diameter was applied, only a small portion of the boiler shell having been cut away, but the strain at the base of the dome was such that violent leakage ensued, so that no more than 235 pounds pressure could be maintained with the pumping power at command. A second trial was made with this dome, when it had been re-riveted with stouter rivet heads, suited to resist more satisfactorily the strong upward strain that was produced by the internal pressure, and in this case rupture was produced by the tearing of the bottom flange of the dome on the centre line of the boiler at a pressure of 200 pounds. Up to this period the gauging of the flues and ends had been carefully noted, but no signs of distress were discovered, nor had any strain of the flat ends taken place.

The fifth test was made to ascertain the value of a single-riveted joint as compared with a double-riveted one, and it was found that at 250 pounds the leakage at the single-riveted joint was so great that

the pumps were overpowered, and no increase of pressure could be obtained; the double-riveted joint remained quite tight.

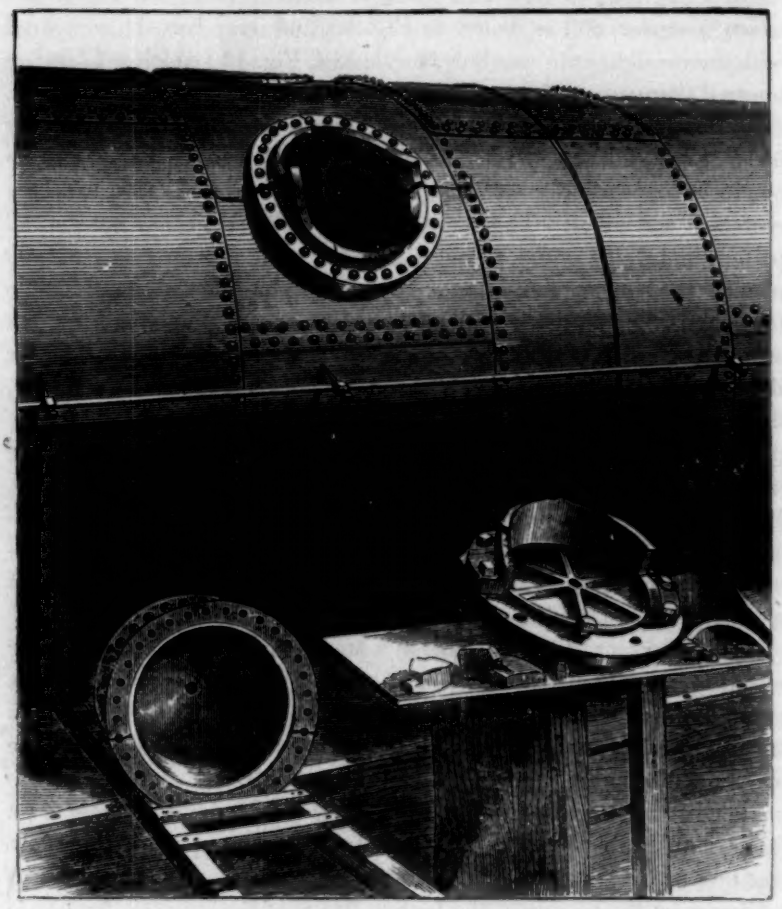


Fig. 9.

The sixth test was to ascertain the strength of an ordinary unguarded manhole with internal door and cross bars, such as have been in time past so very generally used, and are indeed but too often met with even now. The oval hole cut in the shell measured 17 inches by 13 inches, and in this case it must be remembered that the whole apparatus was *new* and of first-rate construction, so far as the imperfect system of such a manhole and cover could be good. The inner cover

lapped well to the boiler shell, and the joint having ample surface, was made with new sheet india-rubber. The cross-bars were of the proper length, so that their feet rested upon the shell plate, not beyond the limit of the cover below, but immediately over the lap, and thus the chances of the door were far above the average rate of strength. There was, of course, no loss of strength from repeated renewal of such a joint or from corrosion, but the door threw out, as is shown in Fig. 12, at a pressure of 200 pounds per square inch, a longitudinal rent starting from one end of the manhole and running across the plate, and then extending some distance along the ring seam of rivets, and fracturing the next plate through a rivet hole.

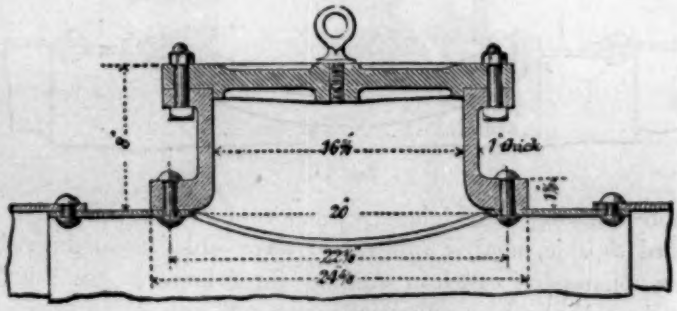


FIG. 10.

Test number seven was a repetition of number five, to try if a *rent* instead of a simple leakage could be produced with a greater amount of pumping power, the idea having arisen that perhaps a single-riveted joint might be taken as a sort of safety valve through which sufficient leakage and relief from pressure might ensue in case of over-pressure, and thus lead to the prevention of actual explosion. Such a theory, if not disproved, might have a very dangerous tendency, and the necessity of complete assurance was felt to be absolute.

With augmented pumping power, this question was set at rest by the complete fracture of a single riveted seam (machine work) at 275 pound pressure, when the rent extended the whole width of the plate, and passed into each side ring plate, the rent being about 5 feet 6 inches long, and such as would most inevitably have caused the whole shell to open out with most destructive results.

Double-riveted work executed by hand was then compared with machine work, with a result similar to the last, in so far as this rent

was very decisive and complete, the hand-worked seam giving way at 300 pounds pressure, while the machine work remained good.

Previously to this there had been some intervening test regarding the stays, after which the longitudinal stay bolts were removed altogether, and the boiler was tested without them from that time to the end of the trials, so far as they have been carried, and no yielding of the ends has yet occurred.

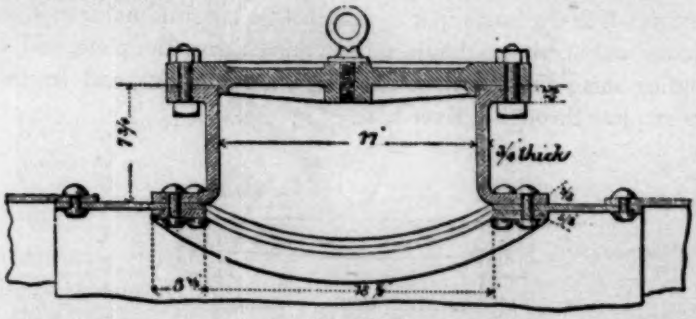


FIG. 11.

Before reaching the highest resistance of which the boiler was reckoned capable, another illustration was afforded as to the risk of placing reliance on cast-iron seatings for fittings to steam boilers. When the boiler had been once again restored with all joints double-riveted by machine, and everything as good as could be, considering the many tests the boiler had gone through, a somewhat unexpected fracture took place in the only remaining external cast-iron seating, viz., that below the boiler at the front end furnished for attaching the blow-off elbow pipe to. At 300 pounds pressure this casting gave way, tearing the shell plate longitudinally, as had been the case in all other such fractures, and straining the lower part of the front plate together with the front internal manhole mouthpiece inwards, and tearing the external angle-iron at the lower part of the boiler.

This had to be repaired, and thus after it had by successive trials been shown that one cast-iron part after another must be discarded, the final burst was attempted, and successfully carried out on the 11th instant, when at 310 pounds pressure a clear longitudinal rent was caused in the central ring of plates, and at the bottom of the boiler, just at the very spot that by all calculation should have been the weakest. Possibly, had the whole boiler been quite new when this last test was applied, and the iron not been subjected to repeated strains closely approaching its limit of strength, the pressure would have reached 320

pounds, or the ultimate calculated strength of the double-riveted joint. Be this as it may, it has now been demonstrated that this form of Lancashire boiler, fairly made, and of good material, is reliable to the extent that calculation would lead one to expect. These experiments were witnessed from time to time by many gentlemen who take a great interest in such matters and stand foremost amongst the engineers

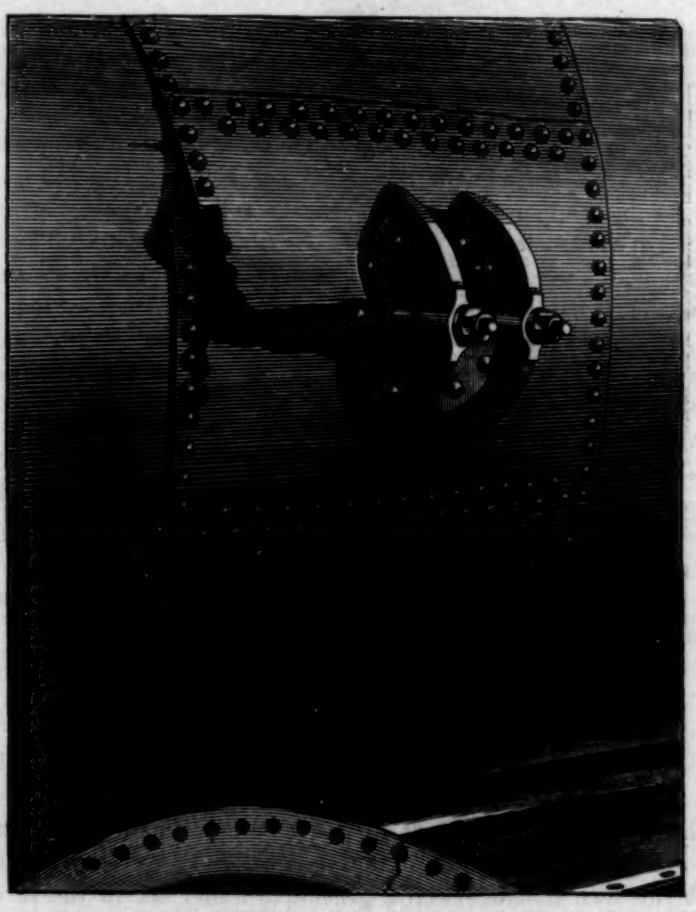


Fig. 12.

of England, amongst whom may be mentioned Mr. J. Ramsbottom, Mr. Turnbull, Mr. Inglis, Mr. Scarlett, Mr. Thomas Traill, Chief Inspector of the Board of Trade, also one of the staff of engineers of *Engineering*. The boiler was made by Mr. Thomas Beeley, of Hyde Junction Iron Works, near Manchester, under the direction of Mr. Lavington E. Fletcher, the Chief Engineer to the Steam Users' Association.

NEW ELECTRIC MOTOR.

By William Woodnutt Griscom.

Paper read before the Franklin Institute Nov. 17th, 1880.

An electric motor, as the name indicates, is an engine for converting electricity into mechanical force. This is done most efficiently through the medium of electro-magnetism, and the honor of inaugurating the movement which has led to the utilization of this force as a motive power belongs to our own Professor Henry. His first paper on this subject appeared in 1831. In the following year Salvatore dal Negro constructed his motor and described it in detail. The first electric motors were rude machines, about as efficient as Hero's steam engine, but it hardly took the world more years to perfect the one than it required centuries to complete the other. Dal Negro's motor consisted of a fixed electro-magnet, which, by suitable interruptions of the electric current, alternately attracted and released a lever by which the mechanism was driven.

In 1835 Prof. Jacobi, of St. Petersburg, constructed an electric engine at the expense of the Czar Nicholas, with which, after four years of further experiment, he was able to drive a twelve-oared boat against the swift current of the Neva at the rate of three miles an hour. His enormous battery consisted of sixty-four cells, containing twenty square feet of platinum.

This was in all respects an apparent failure, and the philosopher was thoroughly disheartened while standing unwittingly on the threshold of a brilliant success. In the first place, he attempted the impossible in trying to get a great power economically from any battery, and in the second place no powerful battery had yet been invented. But his engine was an excellent one, and the subsequent inventors failed to equal it until Gramme, of Paris, discovered that one of his own dynamo-electric generators would act in the reverse direction as an admirable motor.

The interval between 1839, when Jacobi's motor was abandoned, and 1870, when Gramme's machines came into notice, was occupied by a large number of inventors, who brought to their work a world of ingenuity, and all the learning of all the sciences save one, but that

one was the only key to success—*electro-magnetic induction*. In the meanwhile Mr. Joule, himself a former seeker after this nineteenth century philosopher's stone, dashed the hopes of his co-inventors by his demonstration of the Conservation of Energy. This magnificent work, the grandest perhaps in the history of science, was immediately made the basis of a series of experiments, which it would be out of place to detail here. Suffice that Mr. Joule proved to the satisfaction of all scientific minds that the mechanical energy of the electrical current, produced by the consumption of one pound of zinc in a Daniell's cell, is equal to 1,106,160 pounds raised to the height of one foot; in a Grove's cell, which has $1\frac{3}{4}$ times the electro-motive force of Daniell's, to 1,843,600 pounds raised to the height of one foot, or, in the sulpho-chromic acid battery now before you, which has double the electro-motive force of a Daniell's, 2,212,320 pounds raised to the height of one foot. Dr. Scoresby and Mr. Joule state their conclusions in the following sentence: "Upon the whole we feel ourselves justified in fixing the maximum available duty of an electro-magnetic engine, worked by a Daniell's battery, at 80 pounds, raised one foot high for each grain of zinc consumed." This is about half the theoretical duty. In a Grove battery the same proportion would give 144 pounds, and in the sulpho-chromic battery 160 pounds, raised one foot high for each grain of zinc consumed. This result was immediately compared with the duty of the best type of steam engine per grain of coal, and it was found that one grain of coal lifted 143 pounds one foot high. But zinc, at the most favorable computation, costs ten times as much as coal, and the force it yields is, therefore, as 143 is to $\frac{160}{10}$, or about nine times as costly.

The conclusion instantly drawn by the scientific world was that electricity produced by the consumption of zinc can never compete with steam, but it is the purpose of this paper to collect certain facts which will show that this conclusion is erroneous.

History is teeming with instances where noted scientific men declared that there was nothing attainable beyond their immediate vision, and proved with sarcastic argument and brilliant syllogism that further advance in certain directions was impossible. So it was with the steamship. An eminent scholar and mathematician, some fifty years ago, proved beyond the peradventure of a doubt that an ocean steamship was an absurd dream. His calculations showed that one could not be built large enough to carry her own coal across the Atlantic.

And so these gentlemen, having proved that electricity produced by zinc is nine times as costly a source of power as steam produced by coal, predict that electric motors can never usefully compete with steam engines. Now, man-power, according to the tables of a well-known English engineer, is one hundred times as costly as steam; nevertheless there are several circumstances in which we prefer men. It is certain that we would never employ men if we could get a steam engine to do the work more cheaply, and it is equally certain that we would not use electricity where steam was applicable. But steam is *not* applicable, for reasons which will be given later in detail, to work in which we require a small amount of power in constant readiness for action. In these cases—such as jewelers' lathes, dental engines and the various tools of small machine shops, which employ but a small force of men—we have never been able to find a source of power adapted to the work which, if not as cheap in proportion as large steam engines, should yet be more economical than human energy. The fact is that whereas, according to Joule, the best electric motors are nine times as costly as steam power, human energy is eleven times as costly as electricity. And, inasmuch as human energy, which is one hundred times as costly as steam, is frequently preferred to steam engines, *a fortiori* electricity will often be preferred to steam; and it will require no argument to show that the human energy thus saved from exhaustion in the exercise of brute force can be devoted to a higher use.

By way of illustration, the application of human energy to the sewing machine is not only a false economy, but has proved the cause of many new and painful diseases in female operators, which embitter their lives and affect the physique of their offspring. If any motor can be substituted for human energy in this field, there can be no greater or more convincing consideration offered to invite attention to it.

The sewing machine is in almost every house, and the seeds of these diseases are spread in every class of society. The remedy, as before mentioned, is a household motor, and it was natural to suggest a small steam engine for this purpose; but steam is unsuited to this end, because—

1st. It requires time and trouble to start it to work, and a busy housekeeper, who may only need, perhaps, to do five minutes of sewing, has no time to waste.

2d. It is always liable to explode, or to burn out the boiler, or get various portions of its complex mechanism out of order, so as to require an experienced engine driver to repair it.

3d. It emits an offensive odor of burnt or boiling oil, and vitiates the atmosphere with the products of combustion.

4th. It is really much more expensive than those steam engines from which our calculations were made. If gas is consumed for a household engine, the fuel amounts to from twelve to twenty-five feet of gas per hour, costing for a motor giving one thirty-third of a horse-power, as much as the fuel of a six or twelve horse-power steam engine.

This last consideration would not weigh with the actual sufferers of the acute forms of disease, but the other objections are serious, and apply to all heat-motors, such as gas, steam and caloric engines.

Other motors are before the public—the various hydraulic motors which require the special introduction of water-pipe and waste-pipe, and entail yearly visits from those friends of humanity, the plumber and the tax-collector. Then there is the spring motor, which you wind up every quarter of an hour or so, expending, of course, much more power in the winding than you get out of it in work, and which has an unhappy habit of bursting its bonds occasionally and venting its store of energy where it is least needed. Then there is the curious chair motor, whose mechanism is connected with the seat of the chair, and by various levers, cogs, cams and clutch to the sewing machine. The seat of the chair gradually sinks about three inches beneath the weight of the operator, driving the sewing machine the meanwhile. The operator then rises, the spring lifts the seat and the performance is renewed. A rapid speed can be attained by rising and sinking forty times per minute.

It is now fair to examine the theoretical and practical objections to electric motors, used with batteries. They may be divided into two classes—those which utilize the attraction only of an armature to an electro-magnet like the motor which drives the clock in the Institute library up-stairs, and those which utilize the attraction and repulsion of two or more electro-magnets.

The former act by intermittent attraction only, and are wasteful of electric energy, because the residual magnetism, during the interruption of the current, retards the passage of the armature away from the pole which had just attracted it.

Those of the latter type, however, convert a portion of the retarding influence of the residual magnetism into a useful force. In fact, all dynamo-electric generators, when used as motors, convert all magnetic resistance to motion into a counter electro-motive force. At first glance it seems strange to consider a counter force as an economy, but in point of fact it retards the consumption of zinc in the battery and tends to depolarize the negative plate. It has been usual to regard this counter electro-motive force as increased resistance, but a simple experiment will show the error of this view, and will at the same time demonstrate that economical motors must also be efficient dynamo-electric machines in order to recover this force, which would otherwise be lost. A small motor of the type before you was held motionless while a sufficiently powerful current—let us say of four vebers per second—traversed its coils. A tangent galvanometer was in circuit, whose deflection was carefully observed. Then, without changing the connections, the motor was allowed to run at full speed, when the galvanometer indicated about one-fourth of the original amount of current. The electro-motive force of the battery was practically constant, and, therefore, according to the formula

$$\frac{\text{Electro-motive force}}{\text{Resistance}} = \text{Current}$$

the galvanometer should have indicated the same current as at first, unless the resistance had been changed or a counter electro-motive force produced. The speed of rotation was then diminished by a brake, and the needle immediately indicated a greater current. This is in direct conformity with the well-known law that the electro-motive force of a dynamo-electric machine varies with the speed of rotation, whereas the resistance of a coil is not affected by mere motion.

A still more striking proof that the "back-pull" of residual magnetism may be converted usefully into electricity is exemplified in a motor constructed more than a year ago by the writer on the same principle as this one, save that the field-coils are free and not connected with the battery. The current of the battery is sent through the armature, which revolves with considerable rapidity. If the free ends of the field-coils are now connected the speed is immensely increased, and if the ends are separated a spark appears. Of course there is some loss. The entire amount of energy wasted in retarding the armature is not recovered, but nevertheless the increase of power due to this one economy is very astonishing.

The little motor exhibited this evening is also an efficient dynamo-electric machine. The most essential advantage which it possesses over the older forms is in the field magnets. Their peculiar shape is such that all the magnetic lines of force, including those nearest the neutral line, are brought into the best possible position for effecting the revolution of the magnetic armature. I believe that the distinguished inventor, Mr. Ladd, of England, claims, in an article which appeared lately in one of the journals, to have discovered the great advantage possessed by the lines of force of a nearly circular magnet over those in the usual horse shoe form magnet, but he does not appear to have attempted to utilize the lines of force which fill the interior of a curved magnet from the neutral to the polar points. If a bar of soft iron is pivoted at one end, so as to move in a horizontal plane, and a semi-circular magnet is placed concentrically with the circle which the bar can describe, it is found that a given force is exerted upon the bar, at a much greater distance from the poles, when the latter is within the semicircle than when it is without. I believe that no field magnets of this principle have ever before been made, and herein is the secret of the power of this little motor, which weighs about 2½ pounds, and which compares favorably with those of the old forms of fifteen times its weight. The inductive actions which are produced in these field magnets at each revolution of the armature are exceedingly complex, and I shall not trespass further on your attention, except to give a brief resumé of the practical defects of electric motors, and how they have been overcome in the investigation of which this motor is the result.

The great bugbear of those who have used electric motors has been the battery. It gave forth offensive and poisonous vapors; it required almost continual attention; it used concentrated acids, and it became rapidly exhausted whether it was used or not. It was the frequent cause of accidents to clothing, its cells were readily broken and the connections were constantly eaten away.

All these objections are now done away with. The present battery is inclosed in a strong watter-proof box, does not use concentrated acids, gives out no odor, does not exhaust itself, requires renewing only after the fluid is used up by actual work, will last months or years if left to itself and be in as good order as at the beginning. It requires absolutely no attention until the reservoir is exhausted by actual work, and it is ready without a moment's warning at all times and seasons.

It is calculated that the battery will suffice for the sewing of a small family for one year. A professional seamstress would exhaust it more rapidly, but always in proportion to the exact amount of work done. It will be shown that this form of battery places the speed of the motor under complete control without effort on the part of the operator.

The attention of mechanicians is invited to the fact that this form of motor, owing to the force being applied equally to both sides of the shaft at once, entails absolutely no wear on the journals except from the weight of the armature, which is very light, and the tension of the belt, which transmits the power. The length of bearing is four times the diameter of the shaft, and the design of the motor is such that no amount of wear can cause the poles of the armature and magnets to come in contact, which was a frequent source of annoyance in other motors. The motor is attached to the machine, and is of such dimensions as to be readily concealed from view if preferred. There is also a device for readily changing the tension of the belt.

The power of the motor is sufficient to sew leather, or as much tightly woven linen as can be put under the presser. With a sufficient battery power it can give any speed varying from twenty to two thousand stitches per minute in instant obedience to the will of the operator. A safe working speed for constant use is eight hundred to one thousand stitches per minute, which is considerably faster than is now attained by professional sewing women, while others seldom sew more than three hundred to four hundred stitches per minute.

[The principles embodied in the paper were illustrated by a small model weighing 2½ pounds attached to a sewing machine and a battery of six cells, each containing one plate of zinc four inches long and two inches wide. The machine did both light and heavy work, and the speed was under complete control. The battery was sensibly constant, showing no signs of polarization. The current was estimated at two vebers per second, and the force generated at 1000 ft. lbs.] N.

Vapor Tensions at High Temperatures.—Sajotschewsky finds that vapor tension, up to the critical point, is independent of the space occupied by the liquids, but above that temperature the curves, which previously coincided, separated from one another when the quantity of liquid in a given space was made to vary.—*Proc. Vienna Acad.* C

THE SAWYER ELECTRIC LIGHT.

A public exhibition of the Sawyer electric light was given at the Hall of the Franklin Institute on Tuesday evening, Nov. 9th, under the auspices of the company, at which Mr. W. P. Tatham was invited to preside. Mr. Sawyer, though present, was too unwell to address the audience and was obliged to leave before the close of the meeting. In his absence, Mr. Haffey said that the lamps would have to speak for themselves, and showed how they could be turned up or down and regulated to any desired illuminating power by the turning of a switch. He said that Mr. Sawyer and the capitalists connected with him proposed to submit these lamps and dynamo machines to the Franklin Institute for tests as to illuminating power and cost of production, knowing that the Institute could not be bought or influenced in its judgment. He added that Mr. Sawyer was entirely willing to submit to the judgment of the scientific men connected with the Institute.

Description of the Light.

The Sawyer light is designed for household use, and is produced by the incandescence of a small pencil of carbon. It differs essentially from the voltaic arc lights, of great power, such as are exhibited on Chestnut street. The household lamp, which is the principal feature, has a pencil of carbon, about one-sixteenth of an inch in diameter and eight inches in length. This is continuously fed upward by means of a coil spring against a cylinder of carbon probably three-eighths of an inch in diameter. The current of electricity passes without interruption through the upper cylinder of carbon, then through the pencil for about three-eights of an inch, when it passes off into a cylindrical clamp of carbon and through the standards on which the whole apparatus is erected. The carbon pencil is enclosed in a glass shade probably ten inches in height and two and a half inches in diameter, which is sealed and charged with nitrogen. The carbon pencil is gradually consumed, hence the necessity for the spring which feeds it up continuously against the carbon cylinder. The current of electricity meets with such resistance in passing through the part of the pencil three-eighths of an inch in length that it raises it to a white heat, and this is the source of light. The lamps are said to cost from $4 to $6, but

can be manufactured in large numbers at much less cost. No electrical apparatus or clockwork is required to keep the carbons in position, a spring to maintain constant pressure being all that is needed. The larger sized lamps have carbons about one-eighth of an inch in diameter, and the light-giving part is from one to one and a quarter inches in length. The small lamps are reckoned at thirty-candle power, the large ones at 200 or 300, and the inventor claims that he can maintain two of the large lamps or five or six of the small ones per horse-power used in driving the dynamo-electric machine. It is said that the large lamps will run from one to three months without renewal of the carbons, and the small ones from three months to a year, the difference in time being due to the perfection attained in charging the smaller lamps with nitrogen. The cost of renewing the carbons and recharging with nitrogen will probably not exceed fifteen cents. The light of each lamp can be turned up or down at will with as much ease as the light given by a gas burner, resistance being introduced in place of the lamp the light of which is reduced.

Attached to the whole system of lighting is a water regulator, designed to regulate the current in proportion to the use made of it, so that one light or a dozen, or more, in the circuit can be lighted or turned out without affecting the others. The power for doing this is obtained by water pressure, say from a hydrant, a portion of the electric current being used simply to open or close a valve regulating the use of this power. The regulator was out of order, but is intended to introduce or cut off resistance coils, and may be used in practical work to regulate the operations of the steam engine driving the dynamo machines, or to regulate the number of such machines used for generating the current.

Mr. Haffey explained that the power for running the Sawyer dynamo machine furnishing the current was obtained from a bookbindery opposite the Institute, as the engine of the Institute could not be put in condition for the trial, but the latter could be used in making the proposed tests.

Prof. Houston having been called upon said that it was with some reluctance he arose to speak of electric lighting, inasmuch as he had a system of his own, in connection with Prof. Thomson. He had been asked, however, to describe the difference between voltaic arc lights and those produced by incandescence, and would do so.

In the voltaic arc lights there are two electrodes or pencils of carbon,

generally set one above the other, and when the current first passes they are in contact, but are withdrawn by an electro-magnet called into action by the current. The heat developed by the passage of the current from one electrode to the other, when they are separated, vaporizes the carbon and produces the phenomenon known as the voltaic arc. These lights are mainly used for large areas, and clockwork or electro-magnets are used to maintain the carbons at a fixed distance apart during their consumption.

In incandescent lamps there is no separation of the electrodes, but the current passes through some resisting material which is thus raised to a red or to a white heat by incandescence. In this lamp (the Sawyer) the current passes through a thin pencil of carbon, scarcely thicker than the lead in an ordinary pencil. There are a number of systems of incandescent lighting. The main difference between Edison's and Sawyer's lamps is that Mr. Edison uses a medium of very high resistance and puts it in a vacuum, while Mr. Sawyer uses a carbon of comparatively low resistance and puts it in an atmosphere of nitrogen. The Jablochkoff candle is made of two pencils of carbon set side by side and separated by a non-conducting material. In order to start the light a piece of conducting material is laid across between the two carbons. The current passes up one carbon, across the top and down the other carbon. The voltaic arc is soon formed at the top between the two insulated pencils of carbon. The positive electrode, from which the current passes, is consumed about twice as fast as the negative electrode, and with a direct current the candle would burn down more rapidly on one side than on the other. To avoid this the current is alternated so rapidly as not to affect the steadiness of the light, and each carbon being alternately the positive and the negative electrode the consumption is equally maintained.

Prof. Marks inquired whether anything had been determined as to the economy of the Sawyer electric light.

Mr. Tatham, the President, replied that nothing definite was known on the subject, and the cost was yet to be determined.

Mr. Nystrom inquired what was in the tube, and in answer to further inquiries Mr. Haffey stated that the tubes were filled with nitrogen gas at atmospheric pressure.

Mr. Nystrom asked whether, when expanded by heat, the lamps did not break.

Mr. Sawyer said that no lamps had been broken by this or any

other cause, and that the lamps had been kept burning in cold weather in a house on Fifty-fourth street, New York.

Mr. Nystrom said that he could not see any material difference between this light and Mr. Edison's. One used a curved carbon, giving more surface for illumination, and the other a straight carbon.

Mr. Burk said that the essential difference between the Edison and Sawyer lights was that one used carbon under conditions in which it was supposed to be practically indestructible, while the other provided for slow combustion or destruction, with apparatus designed to feed the carbon as it was consumed. In order to have it thus fed it was necessary to use a straight pencil.

Mr. Nystrom made some inquiries as to the life of the carbon in the Sawyer lamp, saying that he had seen a piece of carbon half an inch long broken off in one of the lamps. As he spoke another piece was broken in the large lamp, but the lamp was immediately readjusted automatically.

Mr. Haffey said that the average consumption was not so great as might be supposed from these accidents; that the large lamps, by reason of imperfections in filling them with nitrogen, did not last as long as the small lamps, and that the connections for the large lamp were very imperfect. They were made, in fact, by an assistant holding together two wires, and the irregularity of the light in the larger lamp was due to the imperfect connection thus established.

Mr. Le Van inquired as to how many of the smaller lamps could be maintained per horse-power.

Mr. Sawyer said that the best result he had obtained was seventeen of the small lamps per three horse-power.

Mr. Le Van inquired whether this was indicated horse-power or ascertained by the brake, and when told that it was indicated, he remarked that this was not as satisfactory as the brake.

Prof. Houston said that he thought it was only fair to the systems of electric lighting now in use to add a few words as to their readiness to come before the public. The systems of voltaic arc and incandescent lighting are as old as 1840. The difficulty has been that of securing economy in the production of electricity. Until the invention of the Gramme machine electric lights were produced by batteries. With the discovery of the reaction principle of dynamo-electric machines electric lighting made a great advance. It will not be many years before electric lights take the place of gas. Arc lighting can

now save from fifty to sixty per cent. in the cost where a great deal of gas is used. There will no doubt be great improvements in the next ten years, but there are at present good systems ready for the market. The merit of the system exhibited to-night as an incandescent light is the arrangement in the lamp of a means of correcting itself if any accident should happen. You are not left in darkness if the carbon breaks, but the connection is at once restored. The speaker doubted whether any substance in any attainable vacuum, if raised to high incandescence, could remain unconsumed: he doubted also whether a piling up of the carbon could be prevented. A system which provided for consumption and breakage as does this of Mr. Sawyer's is better. But electric lights of all systems must be known by their fruits.

Mr. Briggs said that he had come to listen, but felt impelled to say something to the large audience which had unfortunately been deprived of a description from Mr. Sawyer. Within four or five years an enormous advance has been made in electric lighting. Step by step electricians have pursued the subject to overcome the disadvantages that have presented themselves, and many have been surmounted. Gas lighting, which was much simpler, required twenty years before it came into practical use. Now we are accustomed to its difficulties and have learned to submit to its evils. And so we will have to get used to this new system of lighting. The absolute amount of power required to produce an electric light is certainly much less than for gas. The thing to be accomplished is the economical division of the electric light. There are several forms of these lights, which Prof. Houston has described, but the voltaic arc lights are not suited to household illumination. These attempts to produce a light which shall overcome present difficulties are to be praised and encouraged, for out of them will come that success of the electric light to which we all look forward.

Mr. McKean having been called upon, said that nothing brought before the meeting seemed to him to have done justice to this light. He had seen the Edison light when it was a toy. It could be turned up and down like this. He had also seen the Brush and other voltaic arc lights, which give forth a great light, which cannot be turned up and down; but this to him had been a very interesting exhibition, because the light was entirely manageable. Here we have lights that will do for small or large rooms in a dwelling. One does not want a light in his chamber like the great voltaic arc lights shown in the

streets or at hotels, but we all want these manageable little lights that can be turned up or down at will. A very great step has been made in providing such a light for use in dwellings.

In answer to inquiries Mr. Haffey stated that one of the lamps had been in use in New York for two months, and that the life of the small lamps was reckoned at about three months or say 300 hours.

Mr. McKean inquired whether the cost of furnishing the light had been ascertained, when Mr. Haffey said that that question could not be answered, but he repeated his desire to have the Franklin Institute take the lamps and answer the question for him, after investigating the subject.

The discussion was closed by Dr. Norris, who stated that he had been informed that the Houston-Thomson lamp was entirely manageable and could be turned up or down at will.

HOT-PRESSED AND COLD-PUNCHED NUTS.

Amongst the most conspicuous and important of American trades is the manufacture of the various descriptions of heavy ironmongery, most of which is peculiarly American in character and application. Besides rails, spikes, wood screws, rivets, washers, etc., are large quantities of bolts and nuts of many different patterns, sorts and sizes, from the tiny ones used for the wagons, houses and furniture of the settler in the remote West, to the large and well-manufactured bolts and nuts employed for railway construction, for timber, bridge or viaduct building, or supplied to mechanical engineers to be finished by the aid of their tools, and ultimately to become component parts of engines or machinery. Where large quantities of bright finished bolts and nuts of the same form and size are in demand, they are frequently supplied completely finished to pattern to the mechanical engineer. The large demand for bolts and nuts and the prohibitory effects of the high rate of import duty have naturally led to a lively competition between manufacturers who seek to distance their rivals by reduction of price, by improved class of product, or by both. A noteworthy instance of this competition has engaged our attention through a trade pamphlet, printed some time ago by Messrs. McLaughlin Brothers, South Third Street, Philadelphia, and issued by Messrs. Hoopes & Townsend, of Buttonwood Street Works, Philadelphia; the

pamphlet itself deserves notice as an instance of the thoroughness and expenditure both of brain and money with which trade is pursued in America. It may be characterized as forming a treatise of sixty-eight pages, with numerous well executed engravings, upon the physical and mechanical properties of bolts and nuts formed by two distinct processes, and contains some points of scientific interest apart from its immediate trading objects. It appears that Mr. Sternbergh, of the Reading Bolt and Nut Works, Pa., is a large manufacturer of bolts and nuts, the latter being forged or hot pressed. Messrs. Hoopes & Townsend are manufacturers at Philadelphia of bolts and nuts, the latter being produced by what is suggested rather than affirmed to be new and peculiar machinery and methods for punching the previously formed nuts cold, that is, at the ordinary temperature of the atmosphere. Great advantages are claimed by the manufacturers as possessed by the nuts thus produced. At the Philadelphia Exhibition both these manufacturers were exhibitors, and some sparring took place arising from statements made in the newspapers as to the rival exhibits which eventuated in a challenge emanating from Mr. Sternbergh, and which was accepted by his rival. The conditions of the challenge competition will best be learned by quoting from Mr. Sternbergh's letter to Professor Thurston, Stevens Institute, Hoboken, N. J., under whose control the contest was ultimately conducted: "The question whether cold-punched or hot-punched nuts are the stronger is of no little interest, especially to the consumer, and one that cannot be determined by an *ex parte* test. I propose that you test the question scientifically and fairly as an expert, and publish the result for the benefit of the public; and, for the purpose, I would propose to roll a bar of iron, one or more sizes, and in the presence of yourself or representative, punch half a dozen or more nuts from each bar, with certain sizes of holes, after my manner of making hot-punched nuts. Then you take the remainder of the same bars down to Philadelphia, and let Hoopes & Townsend punch cold the same number of nuts from the same bars, with exactly the same diameter of holes in your presence, and deliver the nuts to you. Let them furnish their bars also, if they wish, to be punched in your presence by each of us. The nuts to be full thickness, equal to the diameter of their bolts, for say $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, or 1 inch rods, as you prefer. No part of either nuts to be cut away, except so much as may be necessary to make them of equal thickness, then tapped with the same tap, without reaming the hole of either

sort, then tested on steel bolts, turned exactly alike, and the breaking strain of the threads of each sort recorded. Both should be pulled in the direction in which they are punched, or both in the contrary direction, as you prefer, only both alike. Another test would be to have both sorts of nuts of the same diameter, thickness and size of hole, then force a round, conical mandril through them until they split open, keeping a record of the strain, and see which splits open first. Each establishment to be allowed to have a representative present during the fitting up of the nuts and the testing. Bolts made of good chrome steel, I think, would answer to strip the threads. Would you undertake the tests in the interests of the public?"

To this Professor Thurston replied that he should take great interest in the trials proposed, and would be ready to conduct them "in the interest of the public and of truth." The trials were accordingly proceeded with in accordance with the conditions, and in August, 1877, Professor Thurston forwarded an elaborate and exhaustive report of the results, which is given at length in the pamphlet before us. It is not necessary that we should go at any length into this report, some parts of which appear to us drawn out to an amount of minutiæ and prolixity scarcely warranted by the practical importance of the matters referred to. The more important results, however, are thus summarized by Professor Thurston:

"The results of the trial, taken as a whole, are conclusive in proving—First, that the cold-punched nuts possessed a much greater average strength, combined with greater rigidity and slightly greater uniformity than were exhibited by the hot-pressed nuts, and that the superiority was most strongly manifested in the trials by stripping stress. Secondly, that the cold-punched nuts exhibited a strength never attained by the hot-pressed nuts, but that such variations in the strength of both styles occurred as to have caused the hot-pressed nuts to equal and occasionally to excel in strength the weakest specimens of cold-punched nuts."

These experiments appear to have attracted the notice of Professor David Townsend, of the Franklin Institute, who in March, 1878, published a paper in the JOURNAL OF THE FRANKLIN INSTITUTE, under the title of "The Flow of Metals," which forms a valuable supplement in a scientific point of view to Professor Thurston's report. We shall refer to this report more at length: it is enough here to state that he has clearly elicited one or two points in relation to the punch-

ing of metals at ordinary temperatures which are new, or not previously clearly enunciated, and which are of much practical importance to boiler makers, iron bridge builders, and all concerned in the cold-punching of metallic plates. The facts given by Professor Townsend also give us the key or explanation of two of the main facts given but not explained by Professor Thurston, viz., that cold-punched nuts when tapped present a greater resistance than hot-pressed nuts to the stripping of the thread by tension of the bolt, and also a greater resistance to bursting by the forcible intrusion of a conical mandril From the statements of these two documents, respectively, we may take the following as proved: That a well-made steel cylindrical punch can withstand being forced through a much greater thickness of malleable iron at atmospheric temperature than equals its own diameter, contrary to the long received but in every way erroneous empirical rule current among boiler makers and other workmen. Thus a punch of $\frac{7}{16}$ inch in diameter was forced through a rectangular block of iron of $1\frac{3}{16}$ inch thick. In piercing such a block the punch traverses about half the thickness of the block before any punching or core makes its appearance. Detrusion then commences and increases until the remainder of the core is forced out and the hole complete. The flat side of the block at which the punch enters becomes depressed, and the originally flat laminæ are bent down adjacent to the hole into curves, more or less conforming to the saucer-shaped depression given to the top surface and extending to a greater or less depth from the top into the block. From the fact that the punch penetrates to nearly one-half the entire depth before any burr is formed at the lower side, and from experiments made upon the relative specific gravities of the iron of the block, and that of the core forced out of it, it is concluded that during the earlier part of the penetration the metal displaced is forced to flow out laterally around the deeper part of the block, and that the remaining portion of compressed metal, or core, is not forced out until the circumferential resistance of the metal of the block or nut to further outflow equals or exceeds the resistance to shearing of the core from the metal around it. On these facts mainly, it is argued, depends the superior resistance of cold-punched nuts when tapped to "stripping" or "bursting." The bending down of the fibre of the iron all round the hole in the direction in which the punch is moved, so that the fibre, for a portion of the depth of the hole at least, is more or less perpendicular to the faces of the threads when it has been

tapped, is assumed to present a greater resistance to stripping than when the tap has acted upon the fibre arranged in flat laminæ or at right angles to the axis of the hole. Again, the outward flow of metal detruded from the upper portion of the hole into the metal of the block or nut produces increased resistance to bursting, on the same principle as the resistance to bursting in artillery is increased by construction in superimposed rings with initial tension, thus transferring in the case of the nut a part of the bursting strain acting upon the interior of the nut to the exterior portions of the same. In the new Austrian bronze field-artillery, designed by Colonel Uchatius, the initial strain of the outer layers of bronze upon the inner ones, to which the great resistance of these guns to bursting strain depends, is produced by means which almost exactly resemble in principle the results of cold-punching in these nuts. The practical advantages thus obtained are, we may admit, real, though their amount may not be great. The advantages assumed to be gained by the hooking down of the fibre of the nut, so as to approach perpendicularly to the resisting surface of the male screw, seem in no small degree fanciful. This bending, moreover, only applies to a fraction of the entire depth of the nut. The advantage obtained by the outward flow into the nut is probably more important, for no nut bursts, and no stripping of screw threads can take place, with a large amount of resolved strain produced radially by the sliding outwards of the threads of the nut by the pressure upon their inclined faces. The increment of strength, however, obtained by cold-punching from the above-mentioned physical causes, does not seem to be great, and by far the largest proportion of the superiority claimed for the cold-punched nuts seems to be due to the fact that the surface of the hole is perfectly clean and free from scale, while that of the hot-pressed nut is necessarily coated with more or less of hard scale, which may be as hard perhaps as naturally crystallized hematite. In the case of the hot made nut this is broken up by the forcible entrance of the tap, and forced more or less into the substance of the threads of the screw, dependent for their form on that of the tap itself, and upon the degree to which the latter cleanly cuts out the hollows between the threads, or merely moulds by pressure the metal of the nut to fill the spaces between them. But whether forced up or cleanly cut out, the threads of the cold-punched nut must be of solid iron and free from all adventitious mixture of scale, or "Hammerschlag," and in this consists what we deem to be the main advantage of a cold-

punched or drilled nut as compared with a hot-pressed one. A large portion of Professor Thurston's report is devoted to a needlessly prolix record of the experiments made to determine the relative cost of finishing, by machine tool work, the top and bottom faces and the sides of hexagonal nuts, made by both processes, the results being, as might have been anticipated, in favor of the cold-punched nuts. The tapping of any ordinarily proportioned nut constitutes a large proportion of the expenditure necessary for making it a bright finished one, perfect in all respects, and it is obvious that a nut, having a hole with clean cut metallic surface, will be tapped with less wear and tear of tools, perhaps even in less time, *i. e.*, admit of more rapid rotation of the tap, and ultimately will produce a better looking, more perfect and more resistant thread than will be produced from a scale-coated hot-pressed nut. But can these advantages be secured in no other way than by cold-punching, which, we apprehend, must be necessarily an expensive process, especially when deep nuts are manufactured—because the cold-punching process cannot be performed except at a very limited rate of speed? All that was meant by the old boiler makers' maxim that the thickness of the plate must not exceed the diameter of the punch, if more exactly expressed, was that with good steel and ordinary iron a punch, worked at the common speed of a punching press, will not stand long except under the boiler makers' condition. But it has long been well known that by forcing the punch much more slowly through the iron, perforations may be produced in plates greatly exceeding in thickness the diameter of the hole punched in them. The late Mr. Hick, of Bolton, showed many years ago that by slowly applied and continued pressure, holes to almost any depth or diameter might be produced, and, by means of the hydraulic press, he forced a disc of steel 6 inches or 8 inches in diameter through a piece of forged iron 2 inches or more in thickness.

Punching is but detrusion or changing the position of the particles of a solid, and time seems to be the only limit to the amount of this change of position producible by a given force. Even the most rigid and brittle bodies change their form without breach of continuity if sufficient time be given for the action of the detrusive force, as is evidenced by the distorted changes of form produced in strong univalve sea-shells, found embedded in laminated rock. It is somewhat remarkable that in neither of the documents to which we have referred do we find the slightest information as to the rate at which the perforation

of these cold-punched nuts is effected, and which, in the absence of any direct information, we are obliged to conclude to be slow. This, as in all other cases of manufacture, means that it is expensive, and may mean that the only real advantages of cold-punching are dearly purchased. Now, the most real of these advantages appears to be the freedom from scale of the hole in the punched nut, and unless the nut itself be punched out from a bar or plate of cold iron its surfaces cannot be free from scale. Now might not the advantage of freedom from scale be obtained much more cheaply than by the cold-punching process, and without any noteworthy deterioration of the resisting properties of the nut when finished? Might not the process of pickling applied to small castings be applied to hot-pressed nuts? We are inclined to think that little if any difference would be found between the cost of tapping and shaping or the perfection of thread attainable between the hot-pressed nut with the scale so removed and cold-pressed nuts. The process would be much more economical, but so simple an expedient would not afford a sufficiently distinctive standpoint upon which to claim superiority.

It is curious to remark that the challenger is not the victorious party in this competition, and considering the indirect or secondary motives which so frequently enter into these trade competitions, where all is ostensibly direct and fair, we are censorious enough to ask, was each party to this challenge so absolutely sure beforehand of winning as to risk the trial and the publication of its results, or was the whole thing but an elaborate puff got up in the best known style of scientific advertisement in which publicity is the main end in view on both sides? Where the average differences in resistance are within the comparatively narrow limits that these experiments indicate, it seems to us to approach special pleading to attach very great importance to the margin of superior resistance in the cold-punched nuts, especially in view of the admission that the abnormal result is occasionally found of a hot-pressed nut equaling or exceeding in resistance the less resistant of the cold-punched nuts. Now what prudent mechanician pushes to so fine a degree the dimensions of his bolts and nuts as to make it vitally important whether their passive strength falls short of or exceeds some assumed standard amount by 3 or 4 per cent.? Might not the advocate of the hot-pressed nut fairly argue that a very small addition to the dimensions of the bolt and nut made by his method will be sufficient to make it equal in all respects to the cold-punched

one; and how few must be the cases in which any practical objection can arise to such small necessary increase in scantling we surely need not urge!

We have for the sake of brevity abstained from reciting any of the numerical results obtained by Professor Thurston, given in his report and in the extensive tables attached to it. We have but scant information as to the hardness or softness, or tensile resistance of the irons respectively supplied by the two parties to the experiments, and here is a case in which variations in the physical properties of the iron employed would be certain greatly to vary the results obtained, as respects both hot and cold made nuts, more especially the latter. The iron of which the native gun barrels were made in India was often found so soft and ductile that a gun barrel could be cleanly severed through by a sword-cut, or even pared with a pen-knife; and we have irons of English make as hard and rigid as some of the varieties of steel. It is unnecessary that we should enlarge upon the differences that would result from experiments such as have been here adverted to, according as the iron employed neared one or other of the limits thus roughly indicated.—*Engineer.*

Combined Induction Machine.—The difficulty of exciting electricity in damp weather, or in rooms where many men are collected, has induced Robert Voss, of Berlin, to combine the Holtz and Topler machines. He retains the usual Holtz form. Instead of the four fixed half discs he uses one whole disc, which has about the same amount of paper covering as the Holtz. Upon this disc there are four tinfoil coverings, which are connected by couples with one another, and also with two brass pieces which are attached to the fixed disc. The pieces of brass upon the circumference of the disc serve as bearers for the gum stirrup in which the metallic brushes are fastened. The revolving disc has six tinfoil coverings, with an equal number of brass springs; the metal brushes press upon these springs. The double conductor of the machine has also two metal brushes rubbing upon the same springs. The free electricity of the air collects upon the tinfoil. In consequence of the turning of the rotating disc, and the contact of the metallic brushes with the brass springs, their electricity is increased and conducted to the paper covering of the fixed disc.—*Dingler's Journal.* C.

ELECTRICITY IN COLLIERIES.

The following letter from Mr. W. H. Preece, President of the Society of Telegraphic Engineers, has lately appeared in the London *Times*:

Several correspondents recently advocated in the *Times* the employment of electricity for illumination in collieries. One suggests that portable lamps made of a battery and a vacuum tube should be employed. Such lamps have been tried frequently, but they have failed from want of permanence in the current and of intensity in the light. I have seen excellent lamps of this form, notably one made by Breguet, of Paris; but they proved much too feeble in illuminating power in practice. Others propose the use of the electric light on the assumption that such a light is safe. It cannot be too strongly insisted that the absolute safety of the electric light is a popular delusion. In the first place, the arc itself is the greatest source of heat which science possesses, and, in the second place, the wires conveying the electric currents that produce the arc may themselves be conveying energy in a form as insecure as a train of gunpowder. The danger of the electric arc is supposed to be removed by its insertion *in vacuo* in hermetically sealed glass bulbs; but what if these bulbs be broken, and what about the difficulty in maintaining the vacuum?

Granting, however, that it be practicable to immure the light in a secure transparent vessel, what about the wires? The currents employed to generate the light are extremely powerful, in some cases many thousand times stronger than those employed to work telegraphs. Not long ago a poor musician in a theatre in Birmingham, and quite recently a Russian sailor on board the *Livadia*, were killed by incautiously seizing upon certain exposed parts of the conductors conveying these currents. The difficulty in maintaining currents in their proper path in telegraphy is very considerable. How much more difficult must it be to maintain those employed for electric lighting! Copper wires are carefully enclosed in india-rubber or gutta-percha coatings, but these insulating coatings are liable to injury; they are inflammable, and if a mere crack or pin-hole were to occur in such a coating, the currents would escape to earth, generating heat and producing fire. This view is not chimerical. Offices have been

set on fire even by the currents employed in telegraphy. I know of two such cases; one in New York, and the other in Boston. It is not at all unlikely that the recent fire at Manchester arose from such a cause. The liability to such accidents is evidently much greater with electric lighting, and it is only technical knowledge and professional skill which can render such currents innocuous even in well-constructed buildings. In mines, however, the difficulty is much greater. There the wires must necessarily be suspended in narrow, frequented galleries close to the damp earth, and be liable to incessant injury, and they could be rendered comparatively safe only by costly cabling. It would be impossible to guarantee absolute security. To light a colliery by electricity would therefore be both costly and dangerous. The popular delusion as to the safety of the electric light is probably due to its being so frequently spoken of as a cold light, the word "cold" being used in its figurative sense of cheerless, the unscientific taking the word in its literal sense.

There is reason to believe that electricity plays another important part in colliery accidents. Some months ago there was a terrible disaster to the Risca colliery in South Wales; over 70 human beings were hurried into eternity. An inquiry was held into the cause of the disaster, and the conclusion arrived at was very unsatisfactory. A well-known telegraph engineer, Mr. Arthur Radcliffe, from evidence collected on the spot, arrived at the conclusion that the mine was discharged by a flash of lightning. He submitted his evidence to me, and I fully concurred with him. All the conditions of such a catastrophe were present. The flash of lightning was seen to strike the head-gear of the shaft immediately before the explosion. This machinery was connected with the bottom of the shaft by several continuous conducting masses. Iron rails, resting on poorly conducting matter, extended thence throughout the galleries. The gas was there, and it only wanted a break of continuity in the metallic masses conveying electricity, of which there were many, to produce sufficient heat to fire the charge. I have no doubt that lightning was the cause of the explosion. These facts were submitted to those who were concerned in the inquiry; but, probably, being incomprehensible to them, they were ridiculed and therefore ignored.

Hence I advocate the employment of well-constructed lightning conductors over the head-gear of shafts to keep electricity out of the

colliery and to insure safety, rather than the erection of conductors along its galleries to convey it in them for purposes of illumination and to court danger.

The following letter by Dr. Siemens is in reply to the above communication:

Mr. W. H. Preece, in addressing you under the title of "Electricity in Collieries," on the 28th of October, points out, very properly, I think, that the employment of the electric light would not be without danger in coal mines, because the electric arc and an accidental spark between conductors would be liable to fire a gaseous explosive compound. When examined before the Royal Commission on Accidents in Mines, I gave evidence to this effect, suggesting only an indirect application of the electric light, by which, if successful, the chances of accident would be minimized. I am not prepared, however to follow Mr. Preece in his assertion that the electric light generally and under ordinary circumstances is an illuminant dangerous to life and property; his statements in this respect have actually caused unnecessary alarm to those who have trusted electricity for the illumination of public buildings. Mr. Preece says that "if a mere crack or pin-hole were to occur in an insulating coating the currents would escape to earth, generating heat and producing fire," emphasizing this statement by asserting that it is not a chimerical one, but the result of practical information of his own. Now, the dynamo-electric current is powerful in the sense of doing a large amount of work, but its intensity is so moderate that it is only by rubbing the two unprotected conductors against one another that vivid sparks are produced. The interposition of a thin shaving of wood or other inflammable substance would in itself supply a sufficient insulating separator to prevent the spark, and I challenge Mr. Preece, notwithstanding his well-known skill as an experimenter, to the production of an igneous discharge through a mere pin-hole in the insulating covering of one or other of the conductors. In practically arranging electric lights for public buildings the insulated conductors are entirely separate, and the likelihood of danger to buildings is absolutely removed by the precautions taken. Mr. Preece's reference to the unfortunate musician and Russian sailor, who appear to have been struck dead by electric discharges while assisting to put up electric lights, is somewhat sensational. They must have been predisposed to succumb to an electric shock, and

must have grasped firmly the two unprotected leading wires with moist hands; for I and many other persons have frequently touched both poles of a powerful dynamo machine without feeling any the worse for it. At the same time there are dangers connected with the establishment of this, as of almost any apparatus or machinery, which do not in any way apply to the user not set upon courting danger. Mr. Preece also charges the electric light with being cold in appearance, but in reality "the greatest source of heat which science possesses." Now, I quite agree with him in this latter proposition, and have, indeed, constructed an electric furnace for fusing highly refractory materials; but I wish to guard against the inference that because the electric arc is hot, electric light must necessarily heat rooms in which it is employed to anything like the same extent as gas or, indeed, any other illuminant. The following simple calculation, based upon actual experiment, will show what is the relative heating effect of the two sources of light within a room. To produce 4000-candle power by electricity requires a current of 34 Webers, which again represents 130 heat-units per minute. To produce the same amount of light by gas takes 200 Argand burners, consuming 16 cubic feet of 20-candle gas per minute, which consumption represents 15,000 heat-units. Some additional heat will be produced in the electric arc, however, by the combustion of the carbon electrodes, which consumption amounts to 6·3 grains of carbon per minute, and will produce in combustion 12·5 heat-units. The total amount of heat produced by the electric arc is, therefore, $130 + 12{\cdot}5 = 142{\cdot}5$ units per minute, or rather less than 1 per cent. of the heat developed with the same amount of light by means of gas. Gas-lights produce, however, the further inconvenience of displacing the oxygen of the air by carbonic acid, and by a minor, but still very sensible amount sulphurous acid.

If this calculation militates against gas as an illuminating agent, it proves, on the other hand, its great value as a heating agent; and just now, when so much is said about the smoke nuisance, I may be allowed to add a few words on that subject. For upwards of 20 years I have been actively engaged upon the development of a system of working furnaces for the manufacture of iron, steel, glass, etc., by means of gas-fuel produced in a simple gas-generating apparatus. Some thousands of these gas-producers are in operation, and furnish daily proof that gas may be used with economical results; and the smoky factory chimney, where it still exists, proves simply a disregard

for the principles of economy. In the year 1853 I was anxious to take a further step in the same direction in proposing to supply towns with heating gas, and, having induced the Town Council of Birmingham to support my plans, measures were taken to obtain Parliamentary power to carry them into effect. It was intended to separate the two constituents of coal by a comparatively inexpensive method, supplying gas of low illuminating, but high heating power to consumers at a cheap rate, and reserving the coke for use in locomotive engines and stoves, for which purpose it is eminently better suited than raw fuel. Unfortunately, the bill was thrown out by a committee of the House of Lords in consequence of the opposition of the existing gas companies, and the proposal has remained in abeyance ever since. While it is admitted by many that gas fuel can be used advantageously for heating furnaces, there still exists great objection to its use upon the domestic hearth, which is one of the largest sources of consumption of raw coal, and certainly the cause of a great amount of smoke in our metropolis. The gas fireplace sometimes used does not meet with public favor, owing to its uncheerful appearance, great consumption of gas, and, most of all, from the smell which frequently results from its use. It is said to produce a "dry" heat—a term which to my mind conveys no definite meaning, seeing that the heat produced by an open fireplace is purely radiated heat, precluding the idea of moisture; but I have observed that in the usual gas grates, consisting of a number of gas jets spread over the grate, and covered in with pumice stone or asbestos, the heavy gases resulting from the combustion descend through the grate bars, and thus find their way into the apartment.

I have lately constructed in my own house gas grates that are certainly free from the defect just named, and which are at the same time economical and cheerful in their appearance. The arrangement consists in substituting for the fire grate below a solid plate, so as to exclude all communication with the atmosphere, except through the front bars.

A gas pipe perforated above with a certain number of small holes is connected to the ordinary gas service. The grate is filled with ordinary gas coke or anthracite, banked up well towards the back. In this way a cheerful fire can be kindled at any time by opening the gas tap and putting a lighted match to the grate. The gas flames, acting only in front of the grate, soon cause the surface of the coke to glow,

without depriving the beholder of the cheerful appearance of the flame. In the course of half an hour the surface of the heap of coke is fairly red hot, throwing out fully as much heat as an ordinary fire, while not a particle of flame or smoke reaches the chimney; the combustion of the gas prevents the rapid consumption of coke in front, and the absence of its consumption towards the back of the fire. When fairly ignited the gas may be almost turned off, because the coke, once well heated, continues its glow by slow combustion with the atmosphere. An ordinary grate may be converted into a coke gas grate as just described at a very trifling cost, and will be found convenient and inexpensive in its use even when using illuminating gas at 3s. 6d. per thousand cubic feet. Its economy will be materially increased by a sort of regenerative arrangement by which the heat gradually accumulating at the back of the fire is utilized to supply the gas flame with a current of hot air—an arrangement which it would take too much space to describe, but which I shall be happy to place at the disposal of the association recently formed with the laudable object of improving our winter atmosphere.

ADULTERATION OF WINES.

The French Government have just passed a most salutary measure, which will have for effect the diminution, if not the complete suppression, of the process known as *plâtrage*, now become an almost constant custom through most of the wine districts of France, and which, from having at first been performed on a very moderate scale, has lately enormously increased, till it has developed into a crying abuse. The *plâtrage* is carried on under the fermentation, and consists in merely sprinkling the grapes, as successive baskets of them are emptied into the fermentation vats, with plaster of Paris—calcium sulphate—(French *plâtre*), mineralogically known as gypsum, or selenite, in fine powder. Now the grape-juice contains several salts of potash, among which the most abundant are the tartrate and bitartrate, and these decompose when placed in contact with the calcium sulphate, forming calcium tartrate—an insoluble salt—and potassium sulphate.

In the case of potassium bitartrate, potassium bisulphate is formed. Now besides the salts of potash above named, the juice of the grape contains grape-sugar, a nitrogenous fermenting principle and an astrin-

gent principle—to which latter new red wines owe much of their harshness—and also a red coloring matter, with which the astringent principle is intimately associated. The fermentation splits up the grape-sugar, as it is well known, into carbonic acid, which escapes with effervescence, and alcohol, which remains dissolved. In pure undoctored wines, in proportion to the development of alcoholic strength, and as the wine by age tends to become more acid, potassium bitartrate separates as a crystalline precipitate, forming the chief constituent of the deposit in the casks known as *lees*, or, when it forms in bottled wines, as the *crust*.

Now the astringent principle which in the red grape is, as we have explained, intimately combined with the coloring matter, seems to be held more or less in solution by the tartrates, and as these subside with age the wine grows less harsh, losing at the same time much of its color, and is said to ripen or grow mellow. As the astringent principle, however, disappears, the wine, if it be one of the weaker French wines, tends to run to the acetous fermentation, and this is why we frequently find a wine become sour and unpalatable shortly after it has mellowed with age and arrived at its maximum of perfection. Many a bin of valuable claret or Burgundy has thus suddenly surprised and disappointed its possessor, changing in the short space of a few months from fine mellow wine to undrinkable vinegar.

Now, as stated above, calcium sulphate (*plâtre*) decomposes the potassium tartrates, and by withdrawing them and substituting the potassium sulphate, tends to prevent much of the coloring and astringent matter from passing into solution, so that this so-called *plâtrage* is nothing more than a means employed by the Bordelais and Burgundians for giving to their wines a fictitious effect of age, and they naturally defend a practice which enables them to bring their wines sooner into the market, economizing their outlay in casks, and diminishing the chances of loss entailed by keeping a large stock of wine on hand. Further, the process lends itself to fraud, permitting the wine merchants of Bordeaux and Burgundy to import the strong, harsh wines of the north of Spain and the southeast of France, which, when blended with the small, poorer wines of the hill districts of their own country, and then being *plâtrés* (that is, agitated with powdered calcium sulphate), become mild and palatable. Thousands of hogsheads of wines thus blended and doctored are annually sold, and too often at the high rates commanded by pure vintage wines. Under the

provisions of the new act no wine is allowed to be brought into commerce if it contains over two grammes of potassium sulphate per litre. Even this proportion is too large, *plâtrage* should be entirely prohibited; but when we consider that wines are now often sold with five or six grammes of this salt to the litre, it was time, indeed, that some measures should be taken. The merchants defend themselves on the basis of the practice being innocuous, and that while it promotes the keeping qualities of the wine, even four grammes of potassium sulphate could do no harm. It is the greatest possible mistake to fancy that *plâtrage* makes wine keep; for, on the contrary, it withdraws from it the astringent principle, a most potent means of its preservation. For a Bordeaux merchant to contend that forty grains of potassium sulphate to the pint of wine is not or cannot be unwholesome, is a thesis which may be agreeable to his pocket, but certainly ought to be discouraged, for, to say the least, it would surely be prejudicial to the stomachs of delicate or dyspeptic consumers. Not very many years since, a case occurred of actual death by poisoning from the administration of a comparatively small dose of potassium sulphate, and this salt is well known in medicine as a drastic and dangerous purgative. We should then be most sincerely grateful to the French Minister of Commerce for the prudent forethought with which he has protected the consumers of French wines from a practice which had grown into a crying abuse, and for giving us one more guarantee for the purity of these wines, justly ranked as the most esteemed that the world produces.—*Nature.*

SPIRAL POLARIZATION.

A beautiful illustration of the laws of polarization of light has lately been made by M. G. Govi. Let a parallel beam of light be passed through a polarizer, then through a thin slice of quartz cut perpendicularly to the optic axis, then through an analyzing Nicol prism. It is seen, as is well known, to be colored. This colored light when passed into a spectroscope gives a spectrum marked by one or more dark bands, corresponding to the particular rays whose relative retardations in passing through the crystal slice have produced interference. These bands are not always in one place; they are displaced right or left (according to whether the crystal is a right-handed or

a left-handed specimen) if either the analyzer or the polarizer be rotated. A slice of quartz about 4·3 millims. thick produces a single band. One of 8·6 millims. produces two bands at once in the visible spectrum, the number of bands being proportional to the thickness of the crystal.

Now suppose a mechanical contrivance by which both the analyzer and the spectrum can be rotated at the same velocity. A direct vision prism attached to the front of the Nicol prism realizes the optical portion of this combination. There will be seen on rotation a circular spectrum, having either red or violet at the centre and either violet or red at its outer circumference. Now since the dark band spoken of is displaced by a quantity proportional to the amount of rotation, interference will take place in this circular spectrum along points which form geometrically a spiral of Archimedes. The persistence of impressions on the retina will enable this dark spiral to be seen in its entirety, provided the rotation be sufficiently rapid. If a thicker piece of quartz be used, giving two, three or four dark bands, the rotation-spectrum will present a most beautiful appearance, being crossed by a two-branched, or three-branched, or four-branched spiral, the separate lines of which proceed from the centre to the circumference. The sense of these dark spirals will change with the sense of the impressed rotation. The effects, says *Nature*, are very striking.

Apparatus for Raising Water by Compressed Air.—Fr. Honigmann connects a series of casks, at various heights, so that the water is forced from cask 1 into cask 2. The expanding air drives the water from cask 2 into the higher cask 3, from cask 3 into cask 4, and so on until the elastic force of the air is entirely exhausted.—*Dingler's Journal.* C.

Flow of Compressed Air in Tubes.—M. E. Stockalper, the chief engineer at Goeschenen, has published the result of experiments made in the tunnel of St. Gothard upon the flow of compressed air in long metallic pipes, for the transmission of motive force. The special and very favorable conditions for performing the experiments, upon a scale which had been previously impossible, entitle his work to great consideration. His pipes were 5122 metres (3·17 miles) long and two decimetres (7·874 inches) diameter, and his results differ a little from those of previous observers.—*L'Echo Industr.* C.

French Lighthouses.—All the lighthouses on the French coast, except three which are provided with the electric light, have been lit since 1873 with lamps burning mineral oil. The luminous intensity of the apparatus has been greatly increased, and notwithstanding the increase a saving has been effected of more than 400,000 francs ($80,000) per annum, or more than 30 per cent. of the cost of illumination with Colga oil. The use of the mineral oil has not caused a single accident in lighthouses, and after some trials it has also been brought into use for floating lights.—*L'Ingen. Unir.* C.

Nickel Plating by Boiling.—Dr. R. Kaizer prepares a bath of pure granulated tin, tartar and water, which he heats to the boiling point and adds a small quantity of pure red-hot nickel oxide. A portion of the nickel is soon dissolved, as is shown by the green color assumed by the liquid which stands upon the grains of tin. If articles of copper or brass are plunged into the bath they become covered, in a few minutes, with a white, beautiful, silvery metallic coating which consists almost entirely of pure nickel. If a little carbonate or tartrate of cobalt is added to the bath a blueish shade, either light or dark, may be given to the coating, which becomes very brilliant when it is properly polished with chalk or with dry sawdust.—*Mitthgn. d. Bayr. Gewerb.* C.

Mineral Wool Packing.—In many cases steam pipes that were wrapped with mineral wool (slag wool) have become deeply rusted. It was at first suspected that the gypsum was the cause of the corrosion of the iron, but a careful analysis has shown that there were no sulphur salts, and it is now supposed that the rusting was due to the hygroscopic character of the wool. The following plan has been contrived for remedying the evil. Two-parted cast iron muffs are screwed upon the ends and in the middle of each tube, which serve as receptacles for wooden laths. The space between these and the tubes is packed tightly with the wool, about 5 centimetres (1·97 in.) thick, and the whole is wrapped at various places with iron wire, so that the envelope is bound fast to the tube. The laths are first soaked in tar, and the wrapping is also varnished with tar and then surrounded with a shell of sheet iron, which is also wound at different places with iron wire. The ends of the shell are placed in the muffs and those are also coated with tar.—*Dingler's Journal.* C.

Gum Dynamite.—M. Leclaire found, in sinking a well through a bank of massive sandstone at Blauzy, that the charge of gum dynamite need be only two-thirds as great as the charge of ordinary dynamite. The first cost, 8.50 francs ($1.70); the second, 7 francs (1.40) per kilogramme (2 2 lbs.). The proportionate expense for equivalent effects is as 17 to 21.—*Mem. de la Soc. des Ing. Civ.* C.

The Diaphote.—Edison, Prof. Perosino at Mondovi, and Dr. H. E. Lichs, of Bethlehem, Pa., have all experimented upon the transmission by telegraphic wires of the forms and colors of objects in the same way as sounds are transmitted by the telephone. They hope to be able to contrive an apparatus by which two persons who are separated by an ocean will be able to see and hear each other.—*Les Mondes.* C.

Statue of Father Secchi.—The Roman municipality has erected a statue to Father Secchi, of heroic size, on the beautiful promenade of the Pincio. The expression of the great astronomer has been copied with wonderful fidelity. His animated eye is fixed upon the Observatory. He wears the Jesuit dress, with an eye-glass attached to a little cord suspended from his neck. His mantle, falling in numerous graceful and natural folds, hangs from the right shoulder.—*Sem. Relig. d'Autun.* C.

Sidewalk Astronomers in Paris.—At a late banquet to the scientific press Camille Flammarion read a letter of thanks, which had been addressed to him by the street exhibitors of telescopes, in which they stated that the number of their patrons had more than doubled since the publication of his *Popular Astronomy.* Some of the instruments upon the Place de la Concorde would not be unworthy of a place in an observatory.—*Les Mondes.* C.

Influence of Colors upon Animal Development.—C. Yungby, experimenting upon marine animals, has confirmed the results of his fresh water experiments. Eggs of *Loligo vulgaris, Sepia officinalis, Rana esculenta, Salmo trutta* and *Cymnea stagnalis* were developed most rapidly by violet and blue lights, while they were retarded by red and green. Scarcely any difference was observable between the yellow and white lights. Unlike his previous experiments, the development, although retarded, was nevertheless accomplished in red and green vessels.—*Comptes Rendus.* C.

Sun Spots in 1879.—Wolf has compared the solar observations at Zurich, Palermo, Rome, Moncalieri, Athens, Madrid, Leipzig, Peckelöh and Washington, obtaining for the epoch of minimum 1878·9. The variations in magnetic declination at Milan, Vienna, Prague, Munich and Christiania indicate the minimum epoch 1878·5. Both results agree in pointing to an epoch of 11·7 years.—*Compt. Rend.* C.

New Method of Road Building.—Oppermann proposes to build highways in two layers: 1, a bed of 15 to 20 centimetres (5·9 to 7·87 inches) of coarse beton with hydraulic mortar; 2, a bed of smaller beton, cemented with a mixture of lime and one-half part of Portland or Boulogne cement and one-half part of slag. The stones in this second bed should be chosen exclusively from the hardest and most flinty varieties.—*Chron. Indust.* C.

New Experiment upon Spectral Rays.—L. Thollon has erected an apparatus for spectroscopic observations upon the hill of the Nice Observatory. He has especially studied a group of four rays situated in the orange, two of which belong to iron and two are telluric. When the rays are received from the centre of the disc the telluric rays are nearly equi-distant from the iron rays; but if the rays are taken from the eastern or western side of the disc the iron rays are displaced while the telluric rays remain invariable. It is thus possible to demonstrate Freau's formula for light, as well as for sound, and daily to submit one of the most important laws of physical astronomy to careful verification.—*Comptes Rendus.* C.

Book Notices.

POTABLE WATER.—How to form a Judgment on the Suitableness of Water for Drinking Purposes. By Charles Ekin, F. C. S. 12mo. J. & A. Churchill. London. 1880.

This little book is addressed to those who practise sanitary water analysis in the hope of doing something toward extricating this important subject out of the unfortunate entanglements in which it has of late years become involved. When chemists of the highest reputation mutually denounce each other's methods of analysis, and each regards the one he himself has invented as "the only trustworthy process in existence;" and when chemists of these several cliques differ so widely in their certified opinions, that samples of the very same

water collected at the same time are considered by one chemist as perfectly wholesome and by another as positively dangerous for drinking, it is not strange that the public are scandalized and declare water analysis an absurdity. This lamentable result has been brought about, to a great extent, we are sorry to say, by a selfish intolerance manifested by both Dr. Edward Frankland and Mr. J. Alfred Wanklyn and their respective partisans. Such opposing factions, for such they really are, unfortunately are by no means unknown in other branches of science, and are to be found in this country as well as in England.

It is sufficient, however, to say here that the effect of such a state of things, probably more than anything else, is to retard the discovery of truth and seriously to check the very desirable popularization of true science.

It is the purpose of Mr. Ekin to endeavor to clear up the atmosphere and to bring into view some of the most important facts to be noted in forming a judgment of a water. For this he appears to be well fitted by a practical experience in the analysis of nearly 2000 samples of water, many of which were well waters, unquestionably intimately connected with typhoid fever and other serious diseases. In a large number of cases he was able to make a personal examination of the premises and he practised chiefly in a district which included within thirty miles radius every geological formation from the chalk down to the silurian. It can scarcely be denied that the latter circumstance is of nearly as much importance as the preceding for the purpose of arriving at general conclusions.

After giving a very brief review of the ordinary sources of supply, and the character of water from each, he proceeds to criticise the merits of the several processes used at the present time to determine the amount of organic impurity. In the course of his remarks he says, "The custom of laying the chief stress on the amount of organic matter, irrespective of its origin, is misleading and fallacious." On another page he states, after speaking of the non-injurious character of even considerable amounts of peat in solution, "On the other hand, it is quite a common thing to find shallow-well waters containing large amounts of nitrates, exceptionally free from organic matter. Waters which have undoubtedly given rise to typhoid fever have been found by the writer over and over again not to contain more than 0·05 parts of albuminoid ammonia per million" (which represents the amount of organic impurity ruled by chemists as perfectly allowable in drinking

water) "and which, notwithstanding their containing a large excess of nitrates, have been passed by analysts of undoubted ability as being fit for drinking purposes." He gives as an instance of this a village situated on the porous Oolite rock, which also strikingly shows how a disagreement of judgment between chemists of high reputation may effectually put a stop to all attempts at sanitary reform in cases greatly in need of it. In this instance, the numerical results of the analyses were identically the same, but the respective opinions founded on the analyses were directly contrary one to the other.

Mr. Ekin records his conclusions in the following terms:

"A fair trial of the different processes leads to the conclusion that all are absolutely worthless so far as distinguishing between organic matter that is dangerous and organic matter that is innoxious is concerned, but that probably all may be relied upon as giving a rough approximation as to whether organic matter is in excess or not. * * * As giving any indication, however, of the wholesomeness of a water they are useless, because both vegetable and animal organic matter (the latter only being dangerous) yield organic carbon and nitrogen and albuminoid ammonia, and in proportions so nearly alike as to be practically undistinguishable."

This statement should be understood to refer to the direct estimation of the organic matter only, without any auxiliary tests. It has been stated by some, but denied by other chemists, that the presence of peat may be detected by the manner in which the albuminoid ammonia distils over. "An excess of organic matter," Mr. Ekin further says, "is not necessarily an objectionable feature in a drinking water, for many of what are confessedly our best and purest supplies contain an excess of organic matter; but neither, on the other hand, is a minimum of organic matter necessarily a satisfactory feature; for water from wells, especially from shallow wells, and which has undeniably given rise to typhoid fever, will frequently be found to contain only a minimum quantity."

"Therefore, the quantity of organic matter a water contains affords no guide" [considered exclusively by itself, our author should have added] "to its wholesomeness and to lay the chief stress on this ingredient, irrespective of other considerations, is as unscientific as it is eminently misleading."

One of the chief points of dispute has been the value of the determination of nitrates, Wanklyn rejecting it as of no value whatever and

Frankland considering it of prime importance, but making use of the results in a way that is very objectionable to represent a part of what he styles "previous sewage contamination." Now nitrates, when in excess of that derived from the natural soil and rain water, generally result from the oxidation of extraneous organic matter, which oxidation is aided by percolation through soil. But although the deeper the well the more thorough the filtration, Mr. Ekin is manifestly right in saying that the danger is only lessened, not removed, and that "experience shows that so far as infected water is concerned no amount of possible percolation will remove the poison."

The objection often heard, that nitrates and nitrites are not of themselves unwholesome is granted as perfectly true, but is nevertheless entirely irrelevant, and shows a complete misapprehension of the main point at issue. Mr. Ekin further states that nitrates in amounts of 0·3 to 0·4 parts per 100,000 are allowable as equivalent to that found under healthy and natural conditions. "When the amount exceeds 0·5 or 0·6 parts it points significantly to dangerous pollution, and examination of the ground almost invariably shows either that the ground has been heavily manured, as in garden ground, or that there is some actual infiltration of sewage."

Our author has stated his case in all probabili ty much too strongly As waters yield an excess of nitrates above the limit named they become *increasingly suspicious*, would have been a much more philosophical statement.

Owing to the possible occurrence naturally in the soil of larger quantities of nitrates than usual, the limit for condemnation should probably be somewhat higher, say from 1·0 to 1·5 parts per 100,000. But in reality *no one figure can be fixed* as a standard for all conditions of soil, etc., but each particular district must be judged on its own merits.

Understanding Mr. Ekin to signify that the determination of organic matter by the Wanklyn or the Frankland process is not wholly without value when taken in connection with the nitrates and nitrites, but may be in very many cases entirely valueless without them, the writer of this critique earnestly recommends this little book to the careful attention of chemists and sanitarians. His own experience in water analysis leads him to coincide very much with the views expressed by Mr. Ekin; at the same time, he wishes that some of his statements had been made in somewhat more guarded language. R. H.

SEWERS AND DRAINS FOR POPULOUS DISTRICTS. By Julius W. Adams, Chief Engineer of the Board of City Works, etc., Brooklyn. 8vo. New York: D. Van Nostrand. 1880.

In the copy of the work before us the publisher could not have incurred censure if the subject matter had been a memoir or poem, so tasteful is the binding, paper and printing, and this would seem to indicate that the intelligence of the reading public no longer consigns such works to an obscure shelf.

The author states in his preface that in 1857 he prepared the plans for the sewering of the city of Brooklyn, covering an area of twenty square miles. It therefore has the advantage of being the production of a practical man of over twenty years' experience, as the title-page states that he is still connected with the City Works and Board of Health of that city. We quote the following paragraph, believing it to be in accord with the views of all who have given the subject any attention:

"The results of all inquiries abundantly demonstrate that drainage and sewerage are essential elements of health in populous districts. Independently of actual loss of life, which so frequently attends their neglect, impaired mental or bodily vigor, arising from the influence of defective drainage and sewage, reduces daily in thousands of cases the capabilities of individuals to such an extent that it may be considered equivalent to a loss of income by the deterioration or diminution it induces in the effective services which each can give to his occupation. Calculated as a matter of profit and loss, everything indicates that the expense required in establishing proper measures to avoid these evils would be far below the loss consequent upon the inefficient arrangement too frequently witnessed at present."

In view of the fact that thus thousands of persons in a large city may, through ignorance or carelessness, have the tone of their health depressed by disregarding the presence of foul air in their houses, and thus form a fertile soil for the germination and propagation of disease by a continuous subjection of their systems to an insidious poison, is it not a serious question whether it is not a subject eminently within the province of legislative action and governmental control, associated as it is, so vitally with the interests of each individual of the community, both as regards contagion and pecuniary loss? for it is not to be forgotten that epidemics are expensive visitations; the question presents itself in this practical form. Were this doctrine enforced, it would doubtless be resisted as an invasion of private rights, and it would be

claimed that unless one directly injured his neighbor he was entitled to maintain any condition of air he saw fit within his own house, and that even the probability of consequences indirectly involving his neighbors would not justify interference. As there is, however, strong cumulative evidence connecting cause and effect, the question resolves itself into one of degree, in fact, whether it could not be pronounced a nuisance, and suppressed under the statutes authorizing the authorities to abate public nuisances.

We regard Mr. Adams' work as a valuable contribution to the literature upon this subject, and we would particularly recommend it for the attractive manner in which the valuable information it contains is conveyed to the reader. We think, however, that upon the important question of a double system of conduits, one being for house sewage and the other for rainfall, our author is mistaken in assuming the strongest reasons in its favor to be the preservation of the rainfall uncontaminated for domestic purposes, and the undiluted house sewage for commercial use; he overlooks what seems to us a far more important reason, and one which he has touched upon incidentally in another part of the work, viz., the self-cleansing feature which would be thus introduced into that portion of the system allotted to house sewage, instead of having a varying water-line in a large sewer, depositing greasy collections at various levels, and leaving them for days to putrefy. By this method they would receive a daily scouring, if properly constructed; thus these immense manufactories of sewer gas which we maintain under our cities would, for several reasons, be rendered much more scientific in their arrangement.

We are strongly inclined to the belief that if the separation were complete, the washings from the street, contaminated only by the manure of animals, etc., for the most part pulverized and acted upon by the sun and air, would not produce sewer gas, even though the streets were neglected, as they so often are; for, from our point of view, the greasy kitchen refuse plays a large part in the contamination of sewers.

We would, in closing, congratulate Mr. Adams upon having produced such an admirable handbook upon a subject the importance of which is appreciated by all classes, and presenting problems which it is of growing importance should be solved. There is also added to the work, as an appendix, a paper upon the main drainage of London, with map, by the Constructing Engineer, Sir Joseph Bazelgette. We

would also direct attention to the fact that the work is embellished by appropriate cuts wherever the subject requires them. W. B. C.

CATALOGUE OF BOOKS AND PAPERS RELATING TO ELECTRICITY, MAGNETISM, THE ELECTRIC TELEGRAPH, ETC., including the Ronalds Library. 8vo. London: E. & F. N. Spon. 1880.

We learn from the preface of this remarkable book that its compilation was commenced many years ago by Sir Francis Ronalds, and was continued up to his death in 1873. The titles of over 13,000 entries are arranged under the authors' names, anonymous books, with some attempt at classification, filling 14 pages alone, and being under a separate heading at an appropriate place in the volume.

An ardent lover of books, and at the same time a great reader of them, the principal occupation of Sir Francis Ronalds, during his residence of many years on the continent, was in the formation of this library and the compilation of the catalogue. Many works belonging to Volta, Arago, Faraday and other distinguished men, are among its treasures. As the date and place of birth and, where possible, of the death of each author have been added, the usefulness of the catalogue has been greatly increased. Papers contributed to transactions and proceedings of learned bodies, scientific periodicals, etc., have also not been forgotten, and the work is a perfect treasure of information to the ambitious student desirous of learning what has been done before him, and a key to unlock a great storehouse of knowledge. We cannot help but congratulate the Society of Telegraphic Engineers, of England, upon having secured this very valuable library, which has taken a lifetime to form, upon the simple conditions of binding the books and printing the catalogue. Originally intended, it is supposed, for the Royal Society, it was represented to its owner that many of the books would be simply duplicates in its already large collection, and when it was bequeathed to his brother-in-law, the latter thought he was best carrying out the views of Sir Francis in giving it to the Society of Telegrapic Engineers upon the above conditions. As the library will be open to the public the wisdom of the choice is apparent, for the best possible use of books is in their diligent study and the application of the lessons of wisdom they teach.

A biographical memoir, giving the leading particulars in the life of this earnest student of science and pioneer in the invention of the electric telegraph, is not the least interesting part of the volume. N.

Franklin Institute.

HALL OF THE INSTITUTE, November 17th, 1880.

The stated meeting was called to order at 8 o'clock P. M., the President, Mr. William P. Tatham, in the chair.

There were present 134 members and 13 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and announced that 19 persons were elected members of the Institute at their last meeting. Also, that he was directed to advertise in the Journal of the Institute the proposed award of the Elliot Cresson gold medal to Mr. Louis S. Spellier for his invention of the Electric Time Telegraph.

The Secretary reported the following donations to the Library:

Specifications and Drawings of Patents, for February, 1880.
From the Commissioner of Patents, Washington.

Bulletin of the Philosophical Society of Washington. Vols. 1 to 3.
From the Society.

Report on the Culture of Sumac in Sicily.
From the Commissioner of Agriculture, Washington.

Proceedings of the Special Meeting of the Board of Supervising Inspectors of Steam Vessels held at Washington. 1880.
From the Board.

Report of the Department of Public Works of the City of New York. From the Department.

Memoir of Joseph Henry. By W. B. Taylor. Washington, 1880.
From the Author.

Summary of Researches in Sound: conducted in the Service of the Lighthouse Board. By Joseph Henry. Washington, 1879.
From the Lighthouse Board.

Philadelphia Water Supply. Report of the Commission of 1878. By Jas. Haworth. From the Author.

Contagious Diseases of Domesticated Animals. Washington, 1880.
From the Commissioner of Agriculture.

Erster Jahresbericht des Vereins für Erdkunde zu Metz, pro 1878.
From the Society.

Burley's United States Centennial Gazetteer and Guide. 1876.
From W. C. Desmond, Philadelphia.

The Millers' Journal and Flour and Grain Reporter. A weekly publication by Howard Lockwood. From Mr. Lockwood.

The American Miller. A monthly journal devoted to the Art and Science of Milling.
From the American Miller Publishing Co., Chicago.

The Daily Miller and Millwright.
From the Miller and Millwright Publishing Co., Cincinnati.

Report of Proceedings of Thirteenth Annual Convention of the American Railway Master Mechanic's Association, May, 1880.
From the Association.

Lecture on the Improvement of the Danube at Vienna. By Sir G. v. Wex. Translated by Geo. Weitzel. From the Translator.

Biographical Sketch of James Aitken Meigs, M.D. By George Hamilton, M.D. From the Author.

Mr. William Woodnutt Griscom, of this city, presented a paper on electric motors (published in another part of the JOURNAL), which was read by the Secretary, and illustrated by the use made of a small motor invented by Mr. Griscom. In this beautiful machine the current is converted into mechanical force by means of an electro-magnet, which, through the action of the commutator, alternately attracts and ceases to attract an armature. Credit was given to Professor Henry for having first used electro-magnetic force as a motive power, and some of the earlier motors of this kind were described. Mention was also made of the fact that Mr. Joule had demonstrated that the force yielded by the consumption of zinc in a battery is nine times as costly as the force yielded by coal used to convert water into steam. It has been concluded from this that electricity from a battery can never compete with steam, but this the paper declared to be an erroneous conclusion, since man power is still more costly, and yet for certain kinds of work and under certain conditions it is employed. The electric motor is particularly designed for household use in driving sewing machines, etc., the advantages claimed for it being readiness at all times to do the work, cleanliness, freedom from danger or disagreeable smells. This motor utilizes the attraction and repulsion of electro-magnets, converting magnetic resistance to motion into a counter-

electro-motive force, thus retarding the consumption of zinc in the battery. A sulpho-chromic battery, enclosed in a water-proof box is used, and, it is said, only requires renewal once in several months, or a year, in proportion to the amount of work done by it. The motor can give any desired speed to a sewing machine, from twenty to two thousand stitches per minute, depending upon the battery power, and this is very simply regulated by the operator pressing upon the treadle of the machine, and so raising or lowering the zinc plates in the battery. The power is sufficient to sew leather, or as much tightly woven linen as can be put under the presser. The motor is very small, not more than four inches long and two or three inches in diameter. It weighs less than three pounds, and is carried on an iron fork on the back of the table of the machine, so that the tension of the belt can be easily regulated. With the battery power used on Wednesday evening, the sewing machine was run at a speed of 800 stitches per minute, which was readily controllable down to 20 stitches per minute.

Mr. Griscom, in answer to queries, stated that each cell of the battery held about a gallon of the solution, that there were six cells with zinc plates, four by two inches, which only required to be amalgamated once. There were two carbon plates to each zinc plate, one on either side. The price of the motor had not yet been fixed, as it has not been put upon the market. As the plates are very small in proportion to the depth of the cells, the battery does not run down soon. Mr. Griscom had had one battery in constant use for ten weeks without changing the solution or renewing the zinc.

Mr. Bullock said that the difficulty about this form of battery had been overcome, as he understood it, by increasing the depth of the cells, the deposit of salts in these deep cells setting up currents which constantly brought fresh liquor to the plates.

Mr. Griscom said that was the true explanation of the maintenance of the battery.

Dr. Norris said that he remembered some experiments he had tried at the Central High School a number of years ago, where the carbon and the zinc were placed in a beaker glass and the bichromate solution then added, the heat from a spirit lamp being used to keep up the circulation of the fluid with the same object as Mr. Bullock had mentioned. He added that there was no objection to the use of a battery for furnishing the current to a domestic motor, as men could be employed to visit houses and attend to the batteries with no more trouble

to the householder than the gas inspector who comes to examine the meter, provided only they were generally used.

The Secretary's report of new inventions included the following: Spellier's Pendelum Suspension applied to small clocks. The object of this compensation is to keep the centre of gravity, regardless of change of temperature, at an equal distance from its centre of oscillation, so its suspension should allow only its recurring oscillation to follow the track of a straight line and to move in one plane only. To give this result it is necessary that the suspending spring should have an even tension. In Spellier's invention you have a contrivance which will automatically adjust the tension of the suspending spring and thus avoid all wobbling motion. As the weight bears equally on either side of the spring, by means of the pulley motion, the tension is adjusted automatically.

A stem-winding clock, imported by the Messrs. Bailey of this city, was also shown. No openings are required upon the dial of the clock which is wound by the keys that can be pushed in and out, and are concealed by the metal frame holding the glass over the face, thus adding much to the beauty of the clock.

An improved folding bed was exhibited by Shupe and Noble. When closed it presented the appearance of a secretary, but was readily opened and changed into a strong bedstead furnished with springs and with room enough inside for a mattrass, bed clothes, etc. These folding bedsteads are made to represent almost any desired piece of furniture, such as a bureau, secretary, sideboard or dresser. The one exhibited was mounted on Martin's patent castors, which were separately shown. These castors have two wheels with a friction wheel directly above the centre of the axis, so that the pressure of the piece of furniture mounted on them is direct. It is claimed that they will sustain great weights and yet move easily.

Attention was called to Professor John M. Child's modification of Galileo's experiment to determine the velocity of a falling body. This apparatus consists of two parallel bars mounted upon a frame so that they may be inclined to the horizon at any angle desired. Two wooden cylinders of the same size, and rigidly fastened to the same axis, roll down the bars. On the axis between the two cylinders is fastened a metal collar which turns freely and which has two arms extending outward. At the ends of the arms are fastened two cords which support the bob of a sand pendulum made of a length to vibrate in

one second. This pendulum swings at right angles to the direction of the motion of the cylinders, and when the cylinders are at rest marks by its sand trace a straight line, an axis of ordinates. On allowing the cylinders to roll down the incline while the pendulum swings, we form a curve which crosses the axis of abscissas at intervals of half a second. The portions of the axis of abscissas contained between these two intersections are found to be proportional to the numbers 1, 3, 5, 7, 9, etc. From the measurements of the curve so formed all the simpler laws of falling bodies may be deduced.

The special merit which the inventor claims for this instrument is that the trace left may be examined at leisure, and thus time is afforded for the mind of the student to grasp the truth elucidated, while the illustration remains before his eyes.

The curve formed by this instrument differs from the simple sinusoid that is formed by the trace of a pendulum moving with uniform motion, in the fact that the abscissas described in the times 1, 2, 3, 4, etc., instead of being proportional to the times, are proportional to their squares, 1, 4, 9, 16, etc. The equation of the curve is, therefore, $y^2 = \text{sine } x$.

This apparatus also affords us a means of computing the distance that a body falls freely by measuring the distance the cylinder rolls in a second, and the angle of elevation of the inclined surface. To attain this result satisfactorily the inclination should be made at least as great as 15° or 20° in order to diminish the retarding effect of rolling friction.

The Secretary presented specimens of graphite, lead pencils, axle grease, etc., from the Dixon Graphite Company of Jersey City.

Mr. Orr inquired where the mineral came from, and Dr. Norris replied that this was the home article, but he believed supplies were also received from Siberia.

Professor Frazer said that some graphite came from the Champlain district of New York, but that some of the finest specimens he had ever seen came from Chester County. Mines near Phœnixville, only a few miles from Philadelphia, furnish much of the best graphite now used.

Mr. Burk exhibited two Jablochkoff candles and described them. He said that they had recently been introduced in this country, and that they were now employed in lighting the store of a silversmith on Chestnut street. Four massive lamps of an ornamental pattern are

used in the store, replacing 120 gas burners. They are said to yield 550 candle power each, and light the store more efficiently than it could be lighted with gas, and without any flare or flickering of the light. The current is furnished by a Siemen's dynamo-electric machine driven by a steam engine of ten-horse power, though it is said only five-horse power is required or used. Each lamp contains six candles, and each candle lasts about an hour and a-half. An automatic arrangement, which may also be operated by hand, switches the current from one candle to another as the one is consumed, so that the light in one lamp can be maintained continously for nine hours. The burned candles are replaced by others at a cost of five cents each. The light given forth through porcelain shades is very soft and agreeable and remarkably steady, notwithstanding the fact that an alternating current is employed, whereby each of the two carbons composing a candle is alternately positive and negative. It is said that there are over two thousand of these lamps in actual use in Europe, but they have only recently been introduced in this country.

Under the head of deferred business, the Secretary read the report of the Committee on Meetings, adverse to the resolution offered by Mr. Eldridge for the printing of reports of papers read at meetings of the Institute.

Professor Frazer's resolution, offered in April last, providing for the appointment of a committee to examine and report upon the methods of testing inks for iron, employed by chemists who testified in the Whittaker will case, was called up. Professor Frazer said that he would have asked for its consideration before, but for the fact that he could not attend at previous meetings. The resolution, he said, was worded rather clumsily and not as he would word it to-day, now that the trial is ended. The object is to ascertain in an authoritative manner the best tests for ink. He had discussed the idea of having a committee of the Institute pass upon the methods of experts before the Whittaker will trial, in the belief that scientists, freed from the restraints put upon them in a court of law, could get rid of a great deal of verbiage on the subject and develop the best methods of analysis. Only a day or two ago he had received a letter inquiring whether certain tests for iron had been disputed by expert chemists. He said that the old objection to the proposed inquiry had passed away, since the law suit had been decided, and he thought the resolution providing for the appointment of a committee ought to be adopted. The reso-

lution for the appointment of the committee was agreed to without dissent.

Notices having been given by Mr. Cooper and Mr. Eldridge of two amendments to the by-laws, one of which prohibited proxies at elections, and the other provided for them, Mr. Cooper explained that at the last election three proxies had been presented, and there being no law on the subject the tellers did not know what to do with them.

Mr. Eldridge said that he had presented his proposed amendments so as to bring both sides of the question before the members. They could adopt one or the other, but in either case they would get a law on the subject.

On motion, it was resolved to publish both notices, so that both amendments would come up at the next meeting to be acted on.

A paper signed by Wm. B. Cooper and Lewis S. Ware was read by the Secretary, advocating the removal of the Institute from its present to more commodious quarters, and the holding of an exhibition next year, from which to raise funds to carry out this purpose.

Mr. Cooper offered a resolution adopting the paper presented by himself and Mr. Ware, and referring the subject matter thereof to a committee of five to be appointed by the President.

Mr. Ware seconded the motion in a speech, showing the danger from fire which the library of the Institute is exposed in its present building.

Prof. Frazer said that it seemed premature at this time to ask the meeting to adopt anything. He could see no objection to the appointment of a committee to consider the subject, but thought that no definite action ought to be taken without such consideration.

Mr. Cooper withdrew that portion of his resolution providing for the adoption by the meeting of the paper presented, and upon motion, it was resolved, that the Chair be authorized to appoint a committee of five members to consider and report at the next meeting upon the communication read.

Mr. Eldridge moved that the subject of the discussion of papers being made the order for the next meeting following the reading, embodied in a resolution previously presented by him, be referred back to the Committee on Meetings, with instructions to consider the advisability of having this made an order of business independent of the question of printing the papers, but it was not agreed to.

On motion the Institute then adjourned.

ISAAC NORRIS, M. D., *Secretary.*